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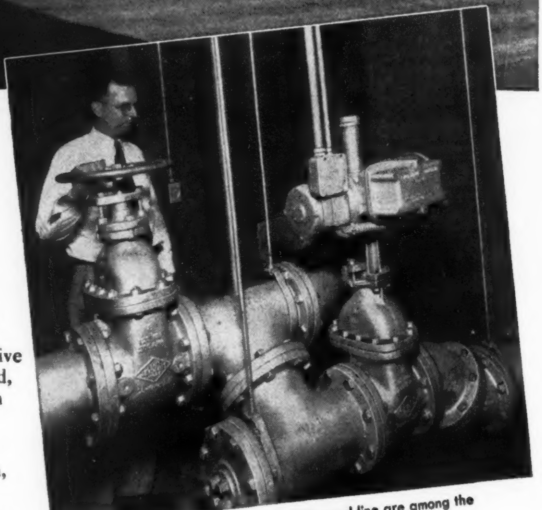

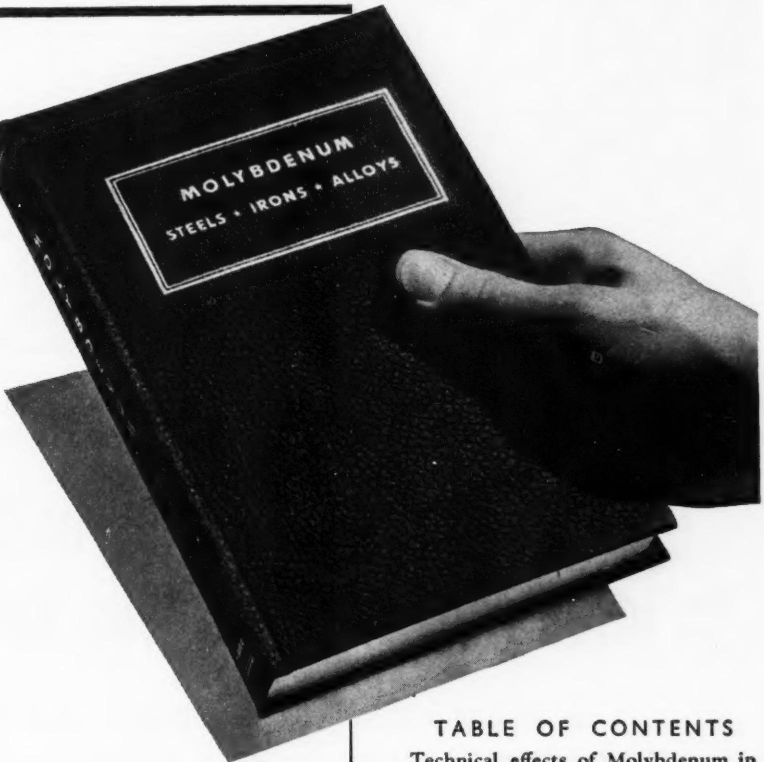

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CONTENTS

Cover—When the sun fades far away . . .
—Critchfield

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AERODYNAMIC THEORY

A Short History and Future of the Theory of Flight

By PROF. WILLIAM R. SEARS

Aerodynamics has its roots in the classical mechanics of the 18th and 19th centuries—namely in classical hydrodynamics. Hydrodynamics began with Bernoulli and Euler, and was developed by Lord Kelvin, Helmholtz, and others. This was a branch of Potential Theory, for it was concerned with the flow of an ideal fluid which was supposed to be incompressible and to have no viscosity.

Now Potential Theory is a branch of mathematics, and so classical hydrodynamics was also a branch of mathematics. These great masters of the 18th and 19th centuries developed the subject to an amazing degree—developed powerful mathematical techniques and very general theorems, so that the flow of such an idealized, incompressible, frictionless fluid around almost any obstacle could be described by their equations. Unfortunately, this being a branch of mathematics, it was not attacked by the combined methods of analysis and experiment, which we know as the "Scientific Method," and before long its results had departed widely from physical reality—since real gases are *not* incompressible, and even liquids, which are nearly incompressible, are *not* free of viscosity.

Practical engineers, who in those days were concerned especially with hydraulics, found little of value in this mathematical discipline, and rejected it categorically. They could not accept, for example, a hydrodynamics which led to the conclusion that there is no force on any body submerged in a steady stream! This situation was changed about the beginning of the 20th century, and the reconciliation between theory and practice was largely due to aeronautics.

Two mathematicians, Joukowsky and Kutta, a Russian and a German, independently discarded one of the basic theorems of hydrodynamics—the one that states that a fluid once irrotational must always remain so—and thus explained the *lift* of a wing. Both were inspired by an interest in flight—Kutta being a friend of Otto Lilienthal, the great German pioneer of flight. In the same period Theodore von Karman, having observed that the flow behind an obstacle is made up of a train of vortices, explained in detail one of the typical cases of *drag. Neither of these important developments required consideration of the viscosity*—in both cases it was only necessary to reject a result of classical theory when it became evident that this result conflicted with physical fact.

The picture was clarified and the gaping holes in the logic of the situation were filled in by the discovery in 1905, by Ludwig Prandtl, of the *boundary layer.* Prandtl's discovery, which has such far-reaching practical and theoretical implications, is one that is almost obvious; that when a fluid of *sm*all viscosity, such as water or air, flows past a solid surface, such as an airplane wing, or the hull of a ship, or the pier of a bridge, only a thin layer of the fluid is affected by viscosity, and all the rest of the fluid behaves like the idealized fluid of the classical hydrodynamicists. It is difficult, now, to see why this beautifully simple result remained hidden until 1905.

We do not have time now to discuss all the implications of this discovery, nor to show how Prandtl proved his result in a set of partial differential equations. These equations explained the presence of von Karman's vortices and they justify Kutta's and Joukowsky's assumption of circulatory flow. In addition, they give the engineer a basic tool to calculate *skin friction* and *heat transfer,* which of course were completely outside the scope of the classical theory.

Prandtl's boundary-layer theory, as I have said, explains the circulation postulated by Kutta and Joukowsky but forbidden by the perfectly logical theory of inviscid fluids. Figure 1 illustrates the mechanism that is involved. The boundary-layer theory states that the layer affected by viscosity will

This article is based on Professor Sears' lecture to the Cornell Chapter of Sigma Xi, February 15, 1951.

ABOUT THE AUTHOR

Professor Sears has been depicted as a human version of an octopus reaching out in all directions for more work. Besides being director of the Graduate School of Aeronautical Engineering, he is on the faculty of the Department of Engineering Physics. He is also the Chairman of the Panel on Aircraft of the Scientific Advisory Board of the Air Force.

He obtained his Bachelor's Degree in Aeronautical Engineering from the University of Minnesota in 1934, and secured a research assistantship at the California Institute of Technology, specializing in wind tunnel work, and within a year was in charge of all such work there. He stayed at Cal. Tech. for eight years, receiving his Ph. D. in 1938, and an appointment as an assistant professor in 1940.

He came to Cornell in 1941 after being Chief of the Aerodynamics Division of Northup Aircraft. Since 1946 he has devoted his time to the new School of Aeronautical Engineering.

....Evacuation of high vacuum electronic tubes prior to sealing and assembly onto its base.

—Westinghouse

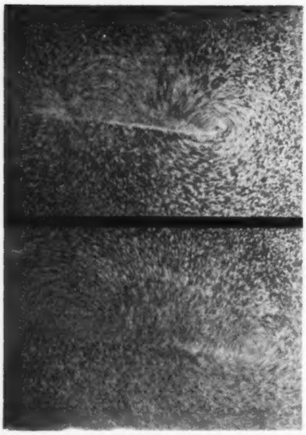


Fig. 1. Flow Photographs showing the origin of "circulation" about a wing abruptly put into motion relative to a fluid.

not be able to negotiate the sharp trailing edge and that an eddy will be shed behind the wing. But the classical theory, which still applies outside the bounary layer, asserts that this eddy must be accompanied by a circulatory flow component about the wing, and hence the lift. The pictures in Fig. 1 vertify that this is, in fact, true. These photographs were made by a camera moving with the wing; the fluid motion was made visible by means of suspended particles, and the wing was abruptly put into motion in a fluid otherwise at rest. The upper picture was taken just after the motion started, and a vortex shed at the sharp trailing edge is clearly visible. The lower picture was snapped a short time later and shows that the shed vortex has remained more-or-less fixed in position while the wing has moved away. From this photograph the existence of a circulation about the wing can be clearly deduced.

But Ludwig Prandtl of Göttingen had still another great contribution to make to aerodynamics. Once again combining the implications of the boundary layer and the classical theories, he reasoned that such circulation cannot be confined to the wing, if the wing is of finite extent, but that vortex filaments—in fact, a continuous sheet of such vortices—must trail back from the wing tips, as shown in Fig. 2. The resemblance of this idealized flow picture to the disturbance actually created by a wing near its tips was apparent to Prandtl. Nowadays, many of us have seen these trailing vortices behind the wing tips of airplanes in pull-outs or behind airplanes flying through clouds or smoke, but Prandtl had not!

In the light of this discovery, it was simply necessary to calculate the forces on the wing in the field of flow induced by the trailing vortices; Prandtl did this, and the result is a wing theory that explains *all* the important charactertistics of a real airplane flying in real air. For example, Fig. 3 shows one result, the explanation of the effect of span on drag. In Fig. 3 are plotted the values of the lift (C_L) and drag (C_D) coefficients* measured in tests of wings of many different aspect ratios. (The aspect ratio is the ration $(\text{span})^2/\text{area}$, or the ratio of span to average chord.) Prandtl's theory states that these should all reduce to a single curve if a simple correction is made for the differences of aspect ratio. Figure 3b shows how this theoretical result is verified.

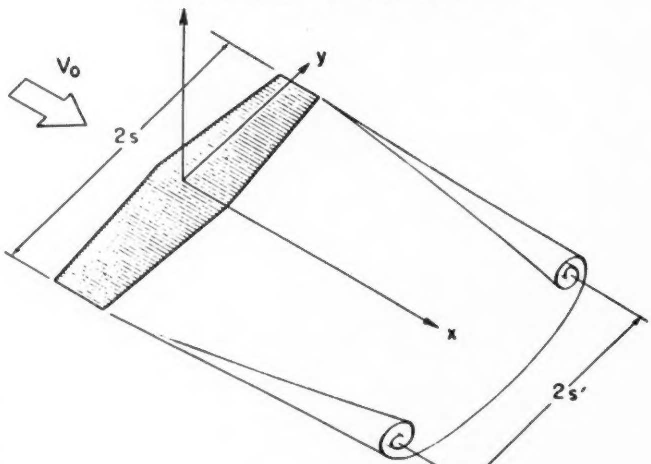
It is hard to over-estimate the importance of this wing theory, which Prandtl worked out in the secrecy of Germany in World War I, in the development of aeronautics between World Wars. All our engineering calculations of performance, of stability and control, and of structural integrity are actually based on it. It has successfully been extended to cases of transient motion, such as maneuvering flight, encounters with gusts, and to explain and predict the destructive phenomenon known as "wing flutter." It has also been extended to propellers, fans, windmills, compressors and turbines—which are all basically wings that follow helical paths and thus leave helical trailing vortices behind them. Thus the modern jet engine owes much of its development to Prandtl. There is no branch of aeronautical engineering that does not continually employ Prandtl's concepts of boundary layer and trailing vortices—and modern hydraulics, hydrodynamics, naval architecture, pump and turbine engineering are almost as deeply dependent.

But in all this we have neglected the compressibility of the air. How can this be, when air is surely a very elastic fluid? It is easy to compress the air inside a tire pump by simply pumping with your finger over the outlet.

A partial answer is that *unconfined* air is not appreciably compressed by objects moving through it at speeds up to about 200 mph. The increase of pressure on the nose of a body at 200 mph at sea level is less than 1 pound per square inch, so that the change in air den-

* Such coefficients are defined as the ratios of the respective forces to the product of wing area and dynamic pressure of the stream.

Figure 2. Wing of finite span with trailing vortices.



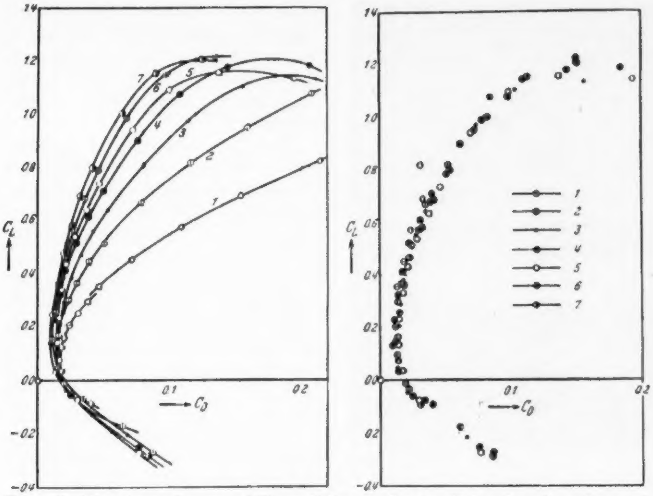


Figure 3a. Experimental curves of lift coefficient vs. drag coefficient for wings of several aspect ratios. In the left-hand graph the values of the test aspect ratios are noted on the curves. Figure 3b. The same curves reduced to aspect ratio of 5 according to Prandtl's lifting-line wing theory.

sity is negligible. Moreover, at still higher speeds the effects of compressibility, while not negligible, can be considered *small* effects, and their implications can be predicted by the same theory of acoustic disturbances that we use to study the propagation of *sound.*

It should be no suprise to you to learn the name of the discoverer of this simple theory—Ludwig Prandtl. It was discovered independently by an Englishman, Glauert, and is known as the Prandtl-Glauert theory.

What is the acoustic theory, basically? It is based simply on the approximation that the disturbances propagate with a constant speed called, for obvious reasons, the *speed of sound.* Starting with this, the theory has been developed into a regular procedure fcr correcting incompressible-flow results. Thus the hydrodynamics of the ideal fluid has not lost its importance in this day of high-speed flight. It no longer tells the whole story, but it is still the starting point for the aeronautical engineer. And Prandtl's beautiful wing theory is thereby extended in validity up to speeds near the speed of sound.

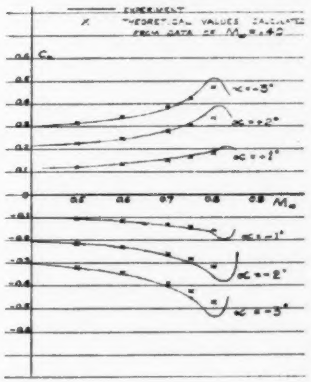
Figure 4 presents some evidence of the utility of this simple theory at speeds of flight up to about 80% of the speed of sound. Here the coefficient of normal force, C*n*, for a wing is plotted against Mach number, M_{∞}, for various angles of incidence a. According to the Prandtl-Glauert theory, the experimental curves should follow the $\times$ points. They very nearly do, as we see, until they break off at a speed of flight approaching the sound speed (Mach number of one). All this is exactly analogous to what occurs when disturbances propagate on the surface of a body of water, and so we can borrow from the realm of hydraulics some simple experiments that will demonstrate the effects in terms of this analogy. Fortunately the hydraulic cases are sometimes easier to visualize, and also to demonstrate, since the speed of surface wave propagation is much less than the speed of sound.

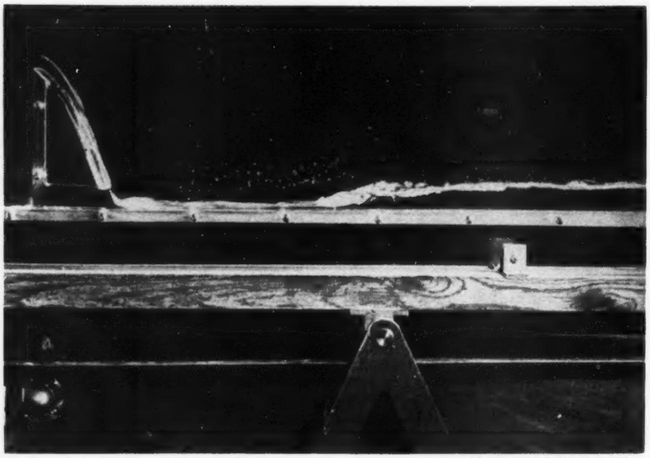
The hydraulic analog of a sound wave is a surface ripple. But when a large disturbance is made in a shallow open basin of water, such as an earthquake on the ocean's bottom, the succession of disturbances produced pile up on one another. This is because, as has already been said above, each of them involves water motion, as well as *wave* motion, and each of them propagates at the ripple speed relative to the moving water. The result is a violent, large disturbance, with nearly a vertical front, called a "bore." If the bore is held stationary by a high-speed stream flowing into it, as in Figure 5, it is called a "hydraulic jump;" it is exactly the same phenomenon. A hydraulic jump is often demonstrated to hydraulics classes, and can be seen just downstream of nearly any spillway. The bore is the analog of a moving shock wave; the hydraulic jump that of a stationary shock wave. The fronts of shock waves are nearly the mathematician's "surfaces of discontinuity," for within them the pressure, density, temperature, and speed of the gas are changed markedly in an incredibly small distance and therefore in an incredibly short time. The transition is accomplished by the familiar mechanisms of viscosity and heat transfer and—in the language of thermodynamics—is highly irreversible.

In Fig. 6 we see a stationary shock wave in a nozzle, quite analogous to the hydraulic jump of Fig. 5. The disturbances upstream (top) of the shock are small ones of the type described by acoustic equations. The shock is obviously a much bigger effect. Here the disturbances have been made visible by the "schlieren" method, which shows up density differences by the same principle that makes rising hot air visible in the sunlight. In Fig. 7 a similar technique has been used to show the pattern of shock waves made by a bullet at supersonic speed. The bow shock is analogous to the bow wave of a high-speed surface vessel.

Now these shock waves are not

Figure 4. Comparison of experimental and theoretical variation of normal-force coefficient of a wing with stream Mach number.





—*Courtesy of Prof. M. S. Priest*

Figure 5. Hydraulic jump produced in a stream downstream of a spillway.

catastrophic occurences on airplanes, as some Sunday newspaper articles might lead you to think. You have probably all heard of the "stone wall" at the speed of sound—when an airplane tried to accelerate through the speed of sound, it was said, it crashed against a "stone wall" of piled-up pressure disturbances and fell in pieces to the ground! Your fears of shock waves have probably been exaggerated by magazine articles about the atomic bomb—how its shock wave destroys buildings. Fortunately our shock waves are considerably weaker—even though there are true stories of rattling windows on the ground near where airplanes have been flight tested at high speeds.

Boundary Layer Separates

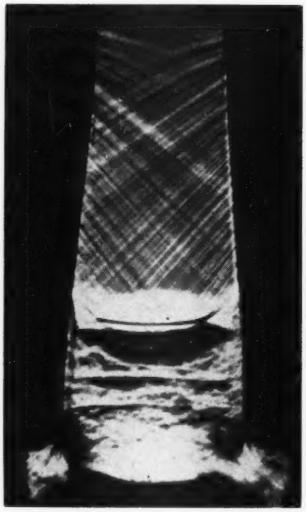
The trouble caused by our shock waves is not a direct result, but comes from an unhappy influence of the waves on the boundary layer. This phenomenon is illustrated in Fig. 8, where the shock wave on a wing flying at high subsonic speed is shown. Where the wave intersects the boundary layer, which is clearly visible in the photograph, the layer is caused to separate; i.e., to depart sharply from the surface, spoiling the flow from that position on back. By this effect, the lift is diminished, the drag is greatly increased, and the aircraft is in danger of being badly put out of equilibrium.

This, not a stone wall, is the source of sonic-speed difficulties. We have some ways of minimizing this; first to postpone the effects to a higher speed—this is the effect of *sweepback* and the reason for using very thin wings—also to design so that the interactions do not occur in sensitive regions; or if necessary, to remove the boundary layer entirely.

Present Day Research

I hope you now have a picture of the present status of aerodynamics. In summary, we have found how to use classical hydrodynamics theory, how to correct it for the presence of boundary layers and compressibility; and finally we have some pretty adequate theories for supersonic flight, and we recognize the phenomena of shock waves and shock-wave boundary-layer interaction.

Figure 6. Stationary shock wave in a divergent nozzle. Flow from top to bottom.



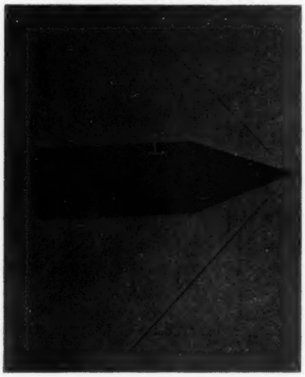
One important area of present-day research involves the extension of all this to higher speeds, higher altitudes, and both higher and lower temperatures. At the high speeds attained by guided missiles, for example, all disturbances must be considered *strong* ones, and all shock waves involve large and fantastically rapid changes of temperature and pressure. At the altitudes reached, on the other hand, air is so rare that it can no longer be considered a continuum—collisions with molecules must be considered actually to occur infrequently!

In the vicinity of such missiles, and especially the high-speed wind tunnels we are building to test them, there will occur such outlandish phenomena as condensation of oxygen and nitrogen—not to mention condensation of any water vapor! If we heat the air of such wind tunnel enough to prevent condensation, it will not only have to be uncomfortably hot (800°F., say) but the rapid processes that occur may leave the gas molecules out of adjustment to their surroundings as they go past the model. This is the phenomenon of heat-capacity lag, and unfortunately its occurrence is not confined to wind tunnels; it also occurs in the engines of supersonic missiles or airplanes.

Generally speaking, the aerodynamicist is being pushed into

(*Continued on page 24*)

Figure 7. Shock waves produced by a bullet at supersonic speeds.



CATIONIC DETERGENTS-I

A Versatile Group of Industrial Chemicals

By THOMAS W. WEBER, ChemE '53

Many people look upon detergents as something quite new to the world—something put on grocers' shelves within the past decade or so. Nothing could be further from the truth. Because much confusion arises as to the differences between soaps, detergents, and surface active agents, some definitions would be helpful.

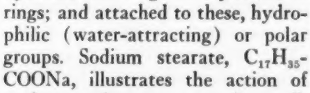
A surface active agent orients itself between two interfaces such that it becomes a coupling agent bringing the interfaces into more intimate contact. If the interface separates a liquid and a gas, a foaming agent results. The interface may also be solid-liquid. Occasionally, surface active agents are found which cause a liquid to wet certain solids selectively while leaving others dry. Advantage is taken of this type of agent in ore flotation processes. In most cases however, the wetting may be quite nonselective. Under these conditions, the function of the agent is described as wetting and penetrating. If, with two immiscible liquids, the surface agent lowers the interfacial tension so that emulsions are formed, the agent is called an emulsifier. If the surface active agent wets and emulsifies to a sufficient degree, and has a few other characteristics too technical to discuss here, it is called a detergent. In short, a detergent is a surface active agent which functions in a special manner.

Soap is a surface active agent exhibiting detergency to such a high degree that it is frequently used as a reference standard for judging this quality in other compounds. On the other hand, the sodium salt of lauryl sulfate and dodecylbenzene sulfonate are also of high quality. These last two, however, differ from soap in two very important respects: they resist decomposition in mild acid solution and their lime and magnesium salts are sufficiently soluble to prevent precipitation in normally hard water. Through long use, the term "synthetic detergent" has come to be assiciated with compounds which exhibit these two properties.

Surface active agents owe their usefulness to their ability to alter the surface energy of their solvents to an extreme degree, even when present in very low concentrations. Generally speaking, they are linear molecules, the most important features of which are greatly hydrophobic (water-repellent) or nonpolar groups, usually long hydrocarbon chains, but sometimes hydrocarbon rings or systems of rings; and attached to these, hydrophilic (water-attracting) or polar groups. Sodium stearate, $C_{17}H_{35}$-COONa, illustrates the action of surface active agents quite well. These molecules orient themselves at the surface of the solution and also at the interface between the soap solution and an immiscible liquid. In each case, the soluble water-attracting group stays in the water surface while the hydrocarbon chain tries to move out of the water surface and into the oil or other immiscible liquid. This reduces surface tension in the first case and interfacial tension in the second. Another important property of surface active agents is their ability to carry into thermodynamically stable solution normally insoluble substances.

Chemical formulae for two common detergents: Sodium lauryl sulfate and cetyl pyridinium chloride.

$$CH_3-(CH_2)_{10}-CH_2-SO_3Na$$



Depending on the nature of the electrical charge on the hydrophobic group or the absence of ionization, detergents have been classified as anionic, cationic, and nonionic. These classes have become one of the most widely used systems of classifying the large numbers of detergents existing today.

After what has been said regarding the high detergent powers of soap, one might well ask what started the synthetic detergent business going, and why is it still growing. Synthetic detergents date back to 1860. In that year the modification of the fatty acid molecule took place with the discovery of the sulfonated fatty oils of which Turkey Red Oil (sulfonated castor oil) —long used in the textile industry— is perhaps the best known. However, World War I furnished the impetus to the research on and production of synthetic detergents because of economic conditions and not to any normal competitive superiority of these compounds. In the few years preceeding the beginning of the War, Germany sought to become economically independent. Expecting a shortage of fats in the event of war, she directed some of her research toward a substitute for soap. The outcome was the development of alkylated naphthalene sulfonates between 1914 and 1918. These found application only for specialized purposes, one of the serious disadvantages being their high cost of production. Since 1925, the line of approach has been the elimination or blocking of the terminal carboxyl groups either by reduction to the alcohol or by esterification or amidation, the object being to join the hydrophobic

group with a solubilizing group, while preserving the stability in acid solution and the stability of the divalent metallic salts. The "Igepons" developed in Germany around 1925 came about from research along these lines. The discovery of petroleum as a readily available and comparative inexpensive source of raw materials for detergent manufacture brought about rapid development prior to 1939; this was accelerated by the fat shortage during the recent war. When long-chain alcohols became available in quantity by the catalytic reduction of fatty acids, a whole group of detergents in this class became available. Their preparation is a direct esterification with sulfuric acid followed by neutralization.

Many synthetic detergents have been found which are better wetting and penetrating agents than soaps. But in addition, some have specific properties which make them useful for specialized cleaning jobs. The cationic detergents are examples of one such group. The cationic detergents or "invert soaps" (as they are often called) have found their particular major spheres of utility within a few short years, and have become well established for certain germicidal and textile finishing applications, while having little or no success in other fields.

If cationic agents differ only in molecular structure from the other types of surface active agents, that difference would, of course, be unimportant. However, the practical differences which result from their structural difference have convinced industrial technologists that in the cation-active agents they have found a new and valuable tool. Some of these cationic characteristics will be discussed in the following paragraphs.

Many of the anion-active agents are deactivated and separate in solutions having pH values much below the neutral point. The fatty-alkyl quaternary ammonium salts —the prominent members of the cationic detergent field—are stable and surface active over a wide pH range on both the acid and alkaline side.

The surface active amines and ammonium ions are strongly adsorbed by siliceous or other negatively charged mineral surfaces. Such mineral surfaces hold the positive surface active ions. These ions, in orienting themselves with the charge-carrying nitrogen at the adsorbing surface, leave their hydrocarbon "tails" extending outward to present an organophilic (or hydrophobic) surface. Thus the fatty amines and their salts have been used to impart water-repellent, organophilic characteristics to cement, asbestos, glass, and masonry surfaces. In the froth flotation concentration of lower-grade phosphate rock using fatty amine salts as collectors, silica is floated from the admixed calcium phosphate. When mineral aggregates used in asphalt road building are first treated with cation-active agents, or if the cation-active agent is first added to the asphalt to be used, the aggregate is more readily wetted and coated by the asphalt, even in the presence of moisture. Subsequent breaking apart or "stripping" of the asphalt from the aggregate is also greatly reduced.

Water Repellent

In a similar manner, it has been found that metallic surfaces by adsorbing the surface-active cations become water-repellent, or organophilic. For instance, iron surfaces treated with solutions of fatty amines, or certain of their salts, resist corrosion and are more easily and thoroughly coated with rust-preventive oils. As an alternate method, the cationic agent has even been incorporated into the oil itself. Paints have been improved by the addition of cation-active agents so that their adhesion and rust-preventive quality when applied to damp, rusty iron surfaces will be enhanced. Inorganic pigments also acquire an organophilic character when treated with cationic agents, and the fatty amines have been used as pigment wetting and grinding aids and as pigment-flushing agents.

Organic surfaces which are naturally electro-negative in character, such as wool and cellulose fibers, adsorb positive surface-active ions. Oil emulsions containing cationic agents are substantive to wool and cellulose materials, i.e., the oil phase of the emulsion exhausts itself upon the textile fibers. For this reason many textile finishing agents are now being made to possess this cationic characteristic in themselves.

The cationic agents change the electrostatic charge on many surfaces. The strong, dust-attracting electro-static charge which accumulates upon many surfaces, especially upon those of synthetic resins and plastics, is eliminated when the surface is coated with a very thin film of cation-active material. Actually a charge of opposite electrical polarity is formed, but this new charge does not attract, and probably repels, normal air-borne dust.

As mentioned previously, the cation-active agents exhibit a high bactericidal activity, and it is this property for which they are known mainly at the present time. All of the fatty amine salts are highly bactericidal, but this quality is particularly outstanding in the quaternary ammonium salts.

Detergents may be used as germicides or as solubilizing, emulsifying, or carrying media for other germicidal compounds. As a carrying medium the detergent may be inert or may act to enhance the active ingredient, increasing its germ killing activity. The broad claims of the germicidal activity made for some of these compounds must be carefully checked. Micro-organisms vary in resistance to the surface active agents. Futhermore, the established methods of testing non-surface active germicides do not always give accurate results when applied to the surface active compounds.

The most potentially powerful bactericidal detergents are the quaternary ammonium compounds. The most widely accepted include the alkyl pyridinium halides and the alkyl-trimethyl-ammonium halides; the cetyl radical gives optimum results. Most of the "quats" marketed as germicides are relatively free of color, odor, and taste in the dilutions normally employed. They are soluble in water and in organic solvents and, as a rule, are relatively non-corrosive. They are usually active in rather high dilution, exhibiting a high antibacterial power against both Gram-positive and Gram-negative organisms. Laboratory results have

(*Continued on page* 40)

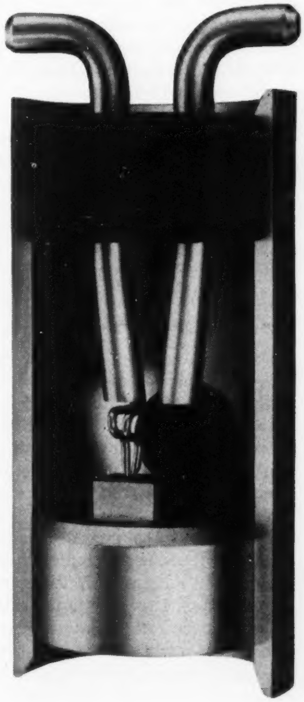
The New Look In Electronics

By GEORGE WOLGA, EP '53

It seems almost ironical that now, at the end of the decade in history which saw the greatest effort and achievements within the field of electronics, that a new development threatens to replace, for many purposes, the most basic tool of the industry—the vacuum tube During World War II, and in the subsequent years after the war, the electronics industry successfully tackled such diverse projects as computors, color television, radar, and many automatic precision devices. Even to contemplate tackling these problems without the use of electronic tubes would have been impossible. Yet today we can say almost with certainty that the vacuum tube is on its way out. We trace this revolution directly to the Bell Telephone Laboratories and the tiny device they developed called the Transistor.

Transistor electronics is an outgrowth of physical research in the field of semi-conductors. Semi-conductors are so named because their electrical properties are intermediate between metals and insulators. They are defined as crystals which are insulators at absolute zero, but which, at higher temperatures, have an electronic conductivity that increases exponentially with the temperature. The semi-conductors used in transistors—silicon and germanium—form what are called covalent crystals wherein the atoms are held together by covalent bonds formed by the valence electrons. In covalent crystals the atoms are held together by "electron-pair bonds" formed by the valence electrons. We can understand this type of bonding better by considering the covalent bond in the hydrogen molecule which is the simplest electron-pair bond. The single electron in the hydrogen atom moves about the single proton in its orbit or quantum mechanical wave function. In an isolated hydrogen atom this wave function has spacial symmetry. However, when two such atoms are brought together there is an interaction of the wave functions thus distorting the symmetry. The result is to produce an added accumulation of charge between the two portions which serves to bind them together in the stable covalent bond. Electrons may be ejected from a bond by external means such as introducing an electric field or allowing radiation to fall on the crystal. Such ejected electrons move about in a region of completed bonds and consequently are free to move in random fashion or in a prescribed path if under the influence of an electric field, thus constituting an electric current.

Type "A" transistor.
—*Bell Laboratories*



Basic to the work on transistors is the theory that electrons can carry current in two ways: one, conduction by excess electrons; the other, deficit conduction, or conduction by holes. An electron deficit, a hole, is a net localized positive charge in the crystal which moves because of the motion of valence electrons.

An everyday analogy may prove useful to explain the mechanism. Suppose a garage floor is completely filled with cars except for a space created by a missing automobile. In the analogy the cars represent electrons and the space the hole. Every time a car moves into the space it leaves behind it the space it just occupied. A series of such movements by the automobiles would serve to move the vacant space all over the floor. In the same way, an electron filling a hole leaves behind it a new hole and thus these positive charges acquire motion within the crystal. The holes contribute to the current by their motion and drift in such a direction as to increase the conventional current caused by electron movement. Whenever an electron drops into a hole, both hole and electron vanish leaving a completed bond structure.

For practical purposes it is desirable to have a surplus of either holes or electrons rather than an equal number of each, for equality in numbers would result in cancellation of charge and termination of conduction. Fortunately, by the addition of certain substances to the semi-conductor it is possible to induce a situation of excess electrons or holes. For example: arsenic yields an excess of free electrons; boron causes an electron deficit or surplus

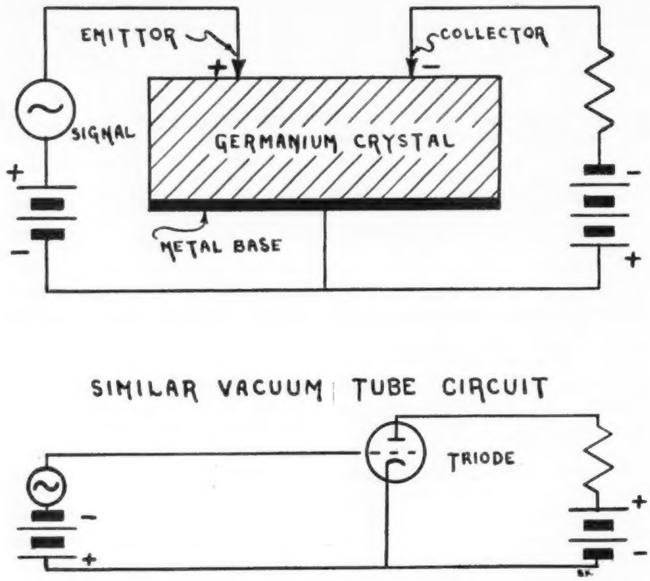


Figure 2. (Top) A circuit using a transistor for amplification. (Bottom) a similar circuit which uses a vacuum tube for the same purpose.

of holes. If the conductivity of a semiconductor is due to excess electrons it is called n-type; if due to holes it is named p-type, the n and p referring to negative and positive.

The transitor's usefulness depends on its ability to amplify electric signals. The amplification process depends a good deal on the physical placement of the transistor components. The type-A transistor, which was the first model experimented with, has three electrodes in contact with a piece of germanium. See Fig. 1. Two of the electrodes are of the point contact type, the third is a large surface, low resistance contact on the base of the germanium. One point contact is called the *emittor,* the other the *collector;* both titles refer to the transmission of current through passage of electrons or holes. It has been found that the current in the forward direction (emitter-germanium-collector) consists largely of holes and that the flow of holes from emitter into collector may alter the normal current flow from base to collector so that the change in collector current is *larger* than the change in emitter current.

The physical basis of this action is the mutual influence exerted when two points such as the emittor-collector system are in close proximity. The collector current produces a field which attracts the positively charged holes flowing from the emitter so that a large part of the emitter current flows to the collector and thence into the collector circuit. This area of mutual influence has been named the "area of interaction" and therein lies the possibility of amplification. A basic amplifying circuit for the transistor is shown in Fig. 2. A similar circuit for vacuum tube amplification is provided in Fig. 2.

Disproves Surface Phenomenon

During the course of further experimentation the observation was made that amplification could be obtained if the emittor and collector points were placed on *opposite* sides of a germanium wedge. The slice of semi-conductor is ground so that it resembles a double concave lens in shape and the contacts are placed in line at the narrowest portion of the wedge. Success with this type of transistor disproved an earlier belief that the current from emitter to collector was a surface phenomenon and thus helped stablize the theoretical aspect of transistor and semi-conductor phenomena. A direct result of the in-line-positioning of the contacts was the development of a coaxial transistor. In this type, the two contacts are each a separate unit which screws into the center piece which holds the germanium wedge. A third and the most recent type of transistor to appear is the junction type about which more will be said later.

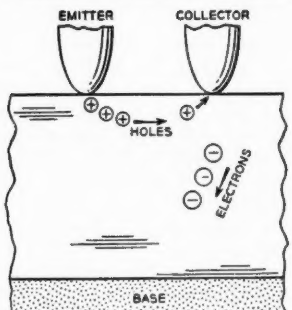
So far, the extravagant statement with which this article opened has been justified with little more than a description of the novel feaures in construction and theory of the transistor.

Vacuum Tubes Inaccurate

To start, we may consider vacuum tubes both from the viewpoint of individual electronic devices and from the industrial standpoint. It should be stated right at the start that vacuum tubes have never been perfected past the point where relatively large tolerances in individual tube performances are expected and tolerated. No matter how painstaking the construction of special tubes, there are branches in the communication field where tubes are not good enough to be used. As an example, the telephone system in two special functions, central office switching and signal amplification on local lines, cannot use electron tubes because they are not sufficiently dependable. Note should be taken at this time that the type-A transistor will be put into trial use in the Bell system next year for specific use in certain complex switching mechanisms previously referred to.

Even at this relatively early date

Figure 1. Schematic representation of flow of electrons and holes in a transistor.



in the history of this device much performance data is available and a direct comparison with vacuum tubes is possible in many considerations. Mention was made previously of amplifying circuits in which the transistor is used in place of a vacuum tube. In analogous fashion to vacuum-tube theory, circuit parameters, equivalent circuits and many of the other calculating aids have been developed for transistors.

The vacuum tube is inherently short-lived and unreliable. Most of its shortcomings are accentuated by the price competition in the electronics industry which necessitates skimping on quality in the interest of less expensive production. Bell Laboratories have already built transistors of the original type which are as uniform in production as vacuum tubes. Transistors can withstand shock and vibration much better than any known vacuum tubes and have anticipated service lives considerably longer than those of commercial tubes. Great stability has been achieved with the junction type transistor whose intrinsic construction features make possible the durability mentioned above. The electrical contacts in this transistor, are between one p-type germanium wedge sandwiched between two n-type wedges. The electrical contact is of the large surface variety and the conduction action takes place over a large area; less power is consumed, the delicate point contact is eliminated, and more efficient operation is achieved. Finally, the tiny unit is encased in a plastic bead which shields the whole mechanism from any external physical stresses.

The mention of power consumption brings to mind one of the most outstanding features of the transistor and a point of great dissimilarity when comparing it with electronic tubes. The transistor has no glass envelope and no vacuum; it has no heating element to cause both warm-up delay and heavy power consumtion. In consequence, the power consumed by a transistor is amazingly low—actually less than one-tenth of that used by an ordinary flashlight bulb. The new junction type transistor operates on one-millionth of a watt, while conventional tubes consume power on the order of a full watt. Since the signal level in modern equipment is approximately one millionth of a watt this means that the transistor uses power of the same magnitude as the signal it produces, which is amazingly efficient operation. The important distinction between transistors and tubes, of course, is that *no* power is needed to free the electrons or holes within the semi-conductor. Power gains of the order of 40-50 decibels per stage have been obtained. This is better than a comparable performance by conventional tubes. Specialization within the transistor family has already begun with special designs such as power transistors accomplishing specific electronic tasks much the same as that which has been done with vacuum tubes.

Smaller Components Needed

Along with excessive power consumption, another great problem in vacuum tube electronics is the rapidly increasing size of electronic equipment. As the design of such equipment becomes more complex its size also increases to the point where it becomes excessively cumbersome, with a consequent diminiation of its practical value. This situaiton has resulted in reduction of size of equipment by the use of printed circuits, miniature tubes, resistors, and other circuit parameters, and cutting down on empty space within the layout of the device.

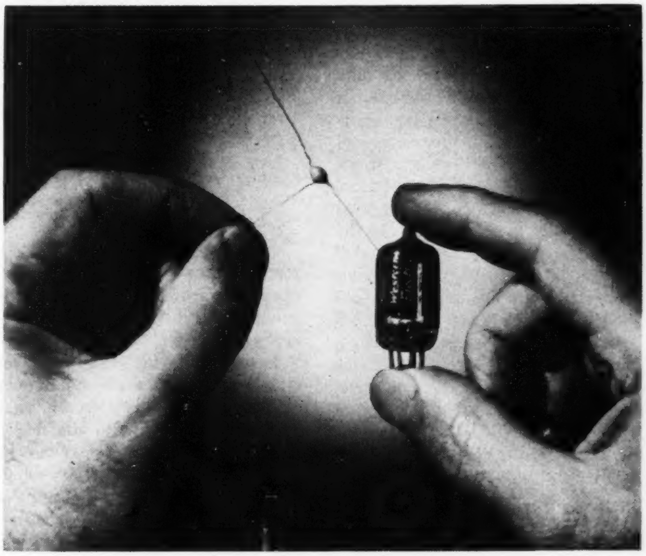
This however, intensifies another major problem, that is, the heat created by the incandescent filaments which are the source of the conduction electrons. The miniature sets use the same amount of power, but with less space for heat dissipation they heat up so much that areas within the equipment reach temperatures greater than 400°F. This in turn creates the problem of special construction utilizing heat resistant materials and also the more rapid deterioration of equipment as a result of heating effects. Obviously this is an unhealthy situation but one which can be considerably improved by using transistors in place of vacuum tubes. A typical transistor occupies approximately .002 cubic inches while the smallest sub-miniature tube with all its disadvantages is about one-eighth cubic inch in volume. Thus we can visualize sets thirty to fifty times smaller than present miniatures, requiring almost no power at all and operating longer, more consistently, and with less sensitivity to shock and vibration while in use.

It would be unfair to emphasize the obvious advantages of the tran-

(*Conitnued on page 44*)

Comparison between junction type transistor and miniature vacuum tube.
RCA Color TV Tube.

—Bell Laboratories



Techni-Briefs

Color TV Battle

The battle over "whose color television gets the nod" from the FCC was recently begun again by the Radio Corporation of America and the Columbia Broadcasting System. In 1950 both RCA and Columbia came out almost simultaneously with systems for color television. The Columbia system of a mechanical color wheel was approved early this year by the FCC "with reservations," after many tests and verbal battles between the two companies.

RCA, claiming that the color wheel system has certain limitations such as inability to pick up black-and-white signals, inability of existing black-and-white sets to pick up Columbia signals, possible mechanical difficulties and inconvenience due to the color wheel; and indirect viewing, has reentered the battle with a new, direct view, color television tube, which has eliminated the haze and fuzziness which prevented the FCC from accepting the RCA tube before.

The new RCA tube is very similar in appearance to a standard black-and-white tube, but has certain modifications of radio circuits and additional tubes in the cabinet to help the color tube perform its function. There were two types of tubes originally, one using a single electron gun to "paint" the pictures, the other using three guns, geared magnetically to actuate each of the three primary colors on the face of the tube. Both tubes have color dots on the face of the tube, old models having 117,000 dots of each primary color, newer models having considerably more. It is in fact this increase in the number of dots, along with certain modifications of the circuits and radio tubing, which has eliminated the haze and improved the resolution which were objectionable in the early models.

The biggest advantages of the RCA tube are that it can receive black-and-white signals without modification, and that standard black-and-white sets can receive RCA signals without modification.

Silicone Rubbers

In recent investigations by the Bureau of Standards, under the joint sponsorship of the Offices of Naval Research and the Quartermaster Corps, it has been shown that silicone rubbers, designed especially for high temperature use, have better low temperature properties than any synthetic or natural rubber studied thus far. This conclusion is based on the extreme low limit of the second order transition temperatures of the silicones (i.e. the temperatures where the sililcone rubbers lose their rubber-like properties).

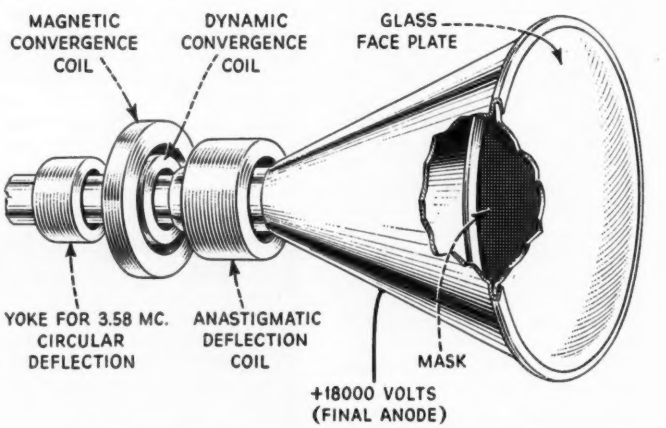
In recent years the need for elastic fitting on arctic equipment and high altitude aircraft has prompted research into the search for a rubber which will not lose its elastic properties at sub-zero temperatures. The ordinary limit of elasticity in natural and synthetic rubbers is about -50°C (-60°F). The silicones' limit was -123°C (-189°F). However, many of the silicones underwent a change of phase at about -70°C (-94°F) which altered their properties considerably. There was one variety, however, which did not undergo this change, and it is believed that this material will be useful at temperatures ranging from -100°C (-148°F) up to 200°C (400°F).

Radioactive Cobalt

Powerful, "supervoltage" rays of radioactive cobalt will soon be studied as a possible new aid to cancer sufferers. Special apparatus for administering the rare isotope will be delivered at Oak Ridge Institute of Nuclear Studies and M. D. Anderson Hospital within the next few months by General Electric X-Ray Corporation of Milwaukee.

The radiation emitted by cobalt 60, as it is known, is equivalent to the x-rays of a 1,200,000 electron volt x-ray tube. While cobalt 60 has been tested on cancer patients before, this new apparatus makes

(Continued on page 48)



Radio Corporation of America's new all electronic color TV tube. —RCA

Harry

PROMINENT ENGINEERS

Harry Henriques

The ChemE school seems to have a special attraction for versatile fellows—especially guitar players. Harry Henriques, one such young man, has an interesting range of talents and accomplishments.

Harry is one of those people who "just happened to come to Cornell" for engineering, not really knowing what he was getting into. He had considered studying at M.I.T., but a state scholarship to Cornell and a perfect score on his high school chemistry regents exam pretty well decided his college career for him. Harry graduated from high school in 1944, but his matriculation at Gornell was delayed by several years' service in the Army, during which he saw quite a lot of New York City and various parts of Texas.

Having distinguished himself in high school track meets in Pelham, N.Y., Harry continued this activity at Cornell. He has run cross-country and the half-mile for the last four years. This year he is serving as assistant track coach along with Charley Moore.

His scholastic ability was recognized by Tau Beta Pi, while his extra-curricular activity on campus resulted in membership in Pros-Ops, of which he is secretary-treasurer. This year, as president of his fraternity, Alpha Sigma Phi, he will have little trouble making good use of his spare time.

Most of Harry's summers have given him little opportunity for mental relaxation. He has been bell-hop and desk clerk at a New Jersey hotel for several summers, though he was employed by a chemistry plant in Massachusetts one summer.

Harry is double-registered in the business school this year. He is definitely not interested in research or sales work after graduation, but hopes to go into production work. Other than that, he has no particular ambition—except that he hopes to avoid any further military service.

Tom Nuttle

At some point in an undergraduate's college career, he can properly look back on his years in College and evaluate his accomplishments. Tom Nuttle, who graduates this February, is now in a position to do just that.

There are three general classes of activities which a student can devote himself to at Cornell: scholastic, extra-curricular and fraternity-sponsored programs. Tom has done remarkably well in all three as attested by his numerous achievements.

As a freshman Tom entered the School of Engineering Physics armed with a Cornell National Scholarship. However, he soon discovered that his interests lay in the more practical technical applications of the civil engineer rather than the theoretical work emphasized in the Engineering Physics program and consequently transferred to the C.E. School. If election to Tau Beta Pi and Chi Epsilon, the civil engineering honorary, means anything, then it would be safe to say that his decision was a wise one.

Tom has an outstanding record in Cornell athletics too, displaying in particular an avid affinity for lacrosse. He has served as captain of both the frosh team and varsity, and won the Larry Woodworth Lacross Trophy last year which is given to the outstanding member of the varsity squad. He culminated his athletic career by being chosen to the North Squad in the annual North-South All-Star Lacrosse game this year.

On campus, Tom was chairman of the Student Council Election Committee in 1948-49 and sub-Chairman of the Frosh Orientation Committee in 1950-'51. In recognition of these achievements he was chosen to Red Key and Sphinx Head, junior and senior honor societies for men.

Tom is also a member of Phi Gamma Delta fraternity and has served as house treasurer and secretary in the past two years.

As his senior project, he worked on the Navy-sponsored project in aerial photography under the faculty direction of Professor Belcher of the Civil Engineering School. Unfortunately, Tom's immediate plans preclude employment in a civilian engineering field as he entered the ROTC program here, and expects to be commissioned in the active reserve this June. It seems certain, though, that after serving Uncle Sam, Tom will find no trouble in making his way in industry and business. Certainly, his excellent record compiled at Cornell would indicate that whichever direction his interests lie in his efforts will be successful.

Tom

Cornell Society of Engineers

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Frederic C. Wood

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students and to establish closer relationship between the college and the alumni."

President's Message

In the year to come, I hope that the undergraduates find a great softening in the hearts of the faculty. I hope that before each examination they find they have in some unknown way gained a great intuitive knowledge of the subject. May their houseparties always turn out to be as good as they expect them to be. May their extra-curricular activities turn out to be most successful.

May the Seniors find it most difficult to bust a course. May their last spring at Ithaca be most beautiful. May the hot and cold wars end. If you go into the Service, I hope it will be just the branch you prefer and that you get to be generals and admirals at the earliest opportunity. Then may you find a good job at high pay with the best company in the world. May you always keep up your membership in the Cornell Society of Engineers.

Not to forget the Professors, here's hoping they will find the students brighter than ever. May they discover a type of examination paper which will correct itself. May the University's income grow and grow and their salaries with it.

For the Alumni, may your income and your profits go up and your taxes come down. May your man win the election in '52. It's my hope that you get the best seats for all the football games next fall and see the Cornell team win all its games.

That seems to be the best message I can give you in December of 1951. Of course, at the same time I would like to wish you a very Merry Christmas and a Happy New Year.

Fred C. Wood

Alumni News

William Metcalf Jr., C.E. '01, is vice-president and director of Wyckoff Steel Co. and a director of United Engineering & Foundry Co. He lives at 642 Grove Street, Sewickley, Pa.

Frank M. Masters, M.E. '05, has published in **Civil Engineering** for October, 1951, an article on the recently-opened Penrose Avenue Bridge in Philadelphia. The new bridge replaces an old span which was unfit because of an accident in 1947. It is two miles long, and perfectly straight.

The Penrose Avenue Bridge crosses the lower Schykill River in Philadelphia near the port facilities, and is near the Philadelphia International Airport. The total cost of the structure was $12,000,000.

Hinman B. Hurlbut, C.E. '01, of 819 Bloomfield Avenue, Montclair, N. J., retired from Government service in June, 1948. He was airways engineer with the Civil Aeronautics Administration.

I. Seeley Jones, M.E. '06, retired in September, 1949, as office engineer in the signal department of Northern Pacific Railway in St. Paul, Minn., after thirty-five years with the company. He lives at 1407 North Avenue 47, Los Angeles 42, Cal.

Albert E. Frosch, C.E. '09, is civilian chief and special consultant to Brigadier General Joel B. Holmes, commanding general of the Ordnance Ammunition Center Joliet Arsenal, Joliet, Ill. Frosch's address is 410 North Raynor Avenue, Joliet, Ill.

James W. Cox, M.E. '09, consulting textile engineer, has been appointed representative of the American Society of Mechanical Engineers on the foreign relations committee of the engineers joint council of the five engineering societies. His address is 40 Worth Street, New York City 13.

Harry Livingston Freeman, M.E. '10, is now working on the problem of natural gas distribution for the Southern Natural Gas Co. in Birmingham, Alabama. He finds time to be active in the Engineers Club of Birmingham and serves as the society's engineering council chairman. After many years as an instructor at Mississippi State College and service in two wars, Harry "relaxes" in his completely equipped machine shop doing woodworking. His address is 1328 Nineteenth Street, Birmingham 3, Alabama.

Mr. H. L. Freeman

W. Bruce Caldwell, M.E. '12, was recently elected president of Borg Warner Corp. Calumet Steel Division, Franklin, Pa. He was vice-president and general manager of both divisions. His address is 6939 South Crandon, Chicago 49, Ill.

Frederick Ohrt, C.E. '11, has been elected Honorary Member of A.S.C.E. His main work for the past quarter-century has been conservation of water resources on Pacific Islands.

He was born in Hawaii when it was still a kingdom, attended the University of Oregon briefly, and received his C. E. degree at Cornell. He completed graduate work at M.I.T.

During his career in Hawii he has been resident engineer on a three-mile water tunnel project, sanitary engineer for the Territorial Board of Health, chief engineer for the City and County of Honolulu, consulting engineer for harbor facilities, and chief engineer for the Honolulu Sewer and Water Commission on modernizing the sewer and water systems.

Mr. Ohrt, as chief of the Board of Water Supply for Honolulu since 1929, has been responsible for much research and construction. He has written several papers on salt-water intrusion, and during the Second World War was a consultant for the Navy at Guam, Saipan, Tinian, and Iwo.

He is active in promoting better government for Hawaii, and is responsible for the present laws on civil service, classification, and the government retirement plan. He joined the A.S.C.E. in 1918, and helped to form the Hawaii Section in 1938. He is also a past president of the Engineering Association of Hawaii.

Joseph S. Thomas, M.E. '27, is director of purchases for Armco Steel Corp. and his address is 311 The Alameda, Middletown ,Ohio.

H. L. Prescott, E.E. '35, of the Transformer Division of the Westinghouse Electric Corporation is the author of an article entitled, "Parallel Tap Changing under Load"

(Continued on page 46)

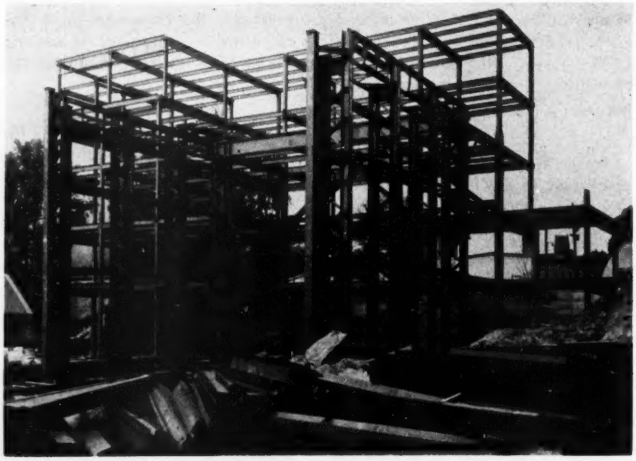
News of the College

Rocket Planned

Among their many and varied accomplishments, Cornellians will soon be able to say that they have a group among them that actually builds and flies rockets. The Cornell Rocket Society has a rocket in the planning stage and hopes to complete and test it by June 1953.

At a meeting November 13, Bill Escher, President, and Ralph Zaganailoff, Project Chairman, explained the basic plan of the rocket, a seven foot liquid propelled rojectile using an alcohol-water mixture and oxygen as fuel. Its design and construction will be split into separate phases, with different members working on such specialized parts as metallurgy, thermodynamics, and stabilization and control. Several of the specifications have already been estimated—the weight filled: 100 pounds—the fuel weight: 50 pounds—the thrust: 300 pounds. Although Professor Martinuzzi, the club's advisor, expressed doubts that a rocket of the size planned would be able to carry 50 pounds of fuel, he said the rocket is definitely feasible and will offer excellent opportunities for fifth-year engineers desiring a stimulating project.

At this same meeting, a film showing the assembly and firing of V-2 rockets was shown. Before the film, Mr. Escher gave an excellent description of the workings of the V-2, enabling those present to better understand the film.

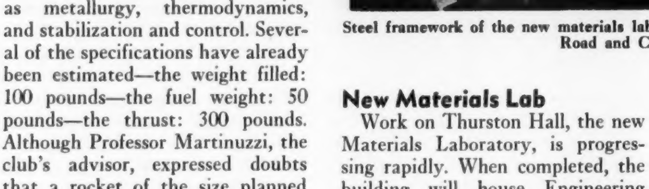


Steel framework of the new materials laboratory, under construction between Campus Road and Cascadilla Gorge.

New Materials Lab

Work on Thurston Hall, the new Materials Laboratory, is progressing rapidly. When completed, the building will house Engineering Materials, Engineering Mechanics, and Structures Research groups. Included are special laboratories designed to study the dynamic properties of materials and structures. Unlike the usual structures laboratory, which provides for a single large testing machine, Thurston Hall will include a specially constructed wing. This wing, approximately sixty feet wide, sixty-five feet deep, and fifty feet high, will serve as a test cell in itself. Anchorages and buttresses will be included as an integral part of this cell that will permit loading from all directions and at all points of the cell. Weighing capsules will also be movable so that an entire structure may be tested at full scale. This makes it possible to test assembled bridges, structural frames, and even complete buildings under both dynamic and static loading.

Schematic diagram of the Rocket Society's Rocket.



EE Panel

On the campus, student members of four engineering organizations presented a panel discussion before freshmen electrical engineers. They discussed the present and future influences that their groups would exert on their members. Those present and the groups they represented were; Roger Thayer, Tau Beta Pi; Herm Hanemann, Eta Kappa Nu; Mert Meeker, A.I.E.E.; and Ed Messenger, I.R.E.

Jorrissen Appointed Head

Professor Andre L. Jorrissen has been appointed head of the Depart-

(*Continued on page* 30)

Editorial

During the past few years, the question of academic freedom on the campuses of universities has risen once again. First, there was the harsh scrutiny of educators who allied themselves with secret government projects; but these investigations are probably justifiable since government agencies have a right to hire only those personnel who may be entrusted with secrets of state. But this search into the background and history of educators has extended its reach onto the campuses themselves, where the position of every faculty member can be placed in jeopardy, according to his past associations and political philosophies, whether or not he continues with these associations or practices his beliefs. To go further, the boards of trustees of some universities prohibit some speakers from even appearing on their campuses, because of questionable political alliances.

Campus newspapers and prominent persons have decried these deplorable conditions; have pointed out this gross transgression of human rights; have argued that the university as the stronghold of knowledge must not allow itself to be dragged into current petty political conflicts. No doubt there is much validity in their arguments. But we wonder how this strikes the average student; whether the distinterested undergraduate regards his university as a citadel of academic freedom. Does he actually believe in these theories of the university? We think not.

For in his position, facing compulsory attendance, unyielding professors, and often seemingly worthless courses, the university he deals with in his everyday life falls short indeed of the vision of the last-ditch fortress of freedom he reads about in his campus newspaper.

Therefore, while academic freedom, the freedom of a university and its faculty, is indeed a virtuous goal to be attained, its attainment may only be the epitomy of hypocracy to the students, who are allowed a minimum of choice, and fall prey to the tyranny of compulsory attendance at classes.

Why is this compulsion necessary? It certainly does not encourage maturity in the student if he is to be spoon-fed. Nor is his knowledge increased if the instructor only repeats what has been said much more clearly in the textbook. Moreover, one can read at the rate of about 350 words per minute, but can only speak at the rate of about 120 words per minute. Thus, a student can accomplish much more by reading than by listening. And too often, professors, knowing their students are trapped, do not attempt to inspire them, and do not bother to go any further into the subject than the course text. Except for the student who needs constant repetition to remember, these classes are a total failure.

Were class attendance made noncompulsory, a drop in attendance would indicate that the professor's lectures could stand improvement, and realizing these shortcomings, he could take the necessary steps to improve them, to the benefit of himself and his students.

In certain courses where attendance is requisite to a proper understanding, as occurs in engineering, we can safely rely on the student's maturity to attend these classes, for one of the prime objects of university life, that being the development of a sense of responsibility, should dictate a sensible attitude towards class attendance.

We think that it is about time that *students* received academic freedom; we see no reason why a good student, doing well in his work must be forced into attendance. And we think that students should be freed from the slavery of being hypnotized to sleep by dull speeches, and, by the same token, be given the opportunity of developing self-reliance. We think that noncompulsory attendance will serve only to improve the welfare of the students, faculty, and the University.

G.S.

Aerodynamic Theory

(*Continued from page* 10)

ranges of pressure and temperature, and rates of physical change, where the physicist and chemist have not yet provided accurate basic data. In our own laboratory here on the campus, for example, we are propagating shock waves at 17 times the speed of sound; these waves are so strong that the gas behind them reaches 30,000°F. The shock wave is in this case a tool to permit study of physical and chemical properties of gases at very high temperatures and undergoing rapid changes of state.

Figure 8. Shock-wave boundary interaction on a wing at high subsonic flight speed.

—*Photo by H. Ashkenas*

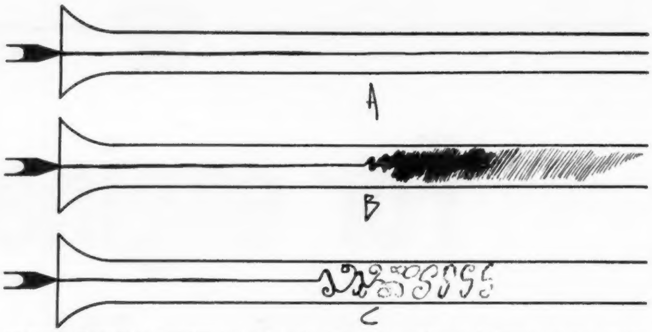


Figure 9. Reynolds' experiment. In (a) the stream is laminar as indicated by the steady dye filiment. In (b) the stream velocite has been increased and turbulence has appeared. (c) Spark photograph of case (b), showing the instantaneous flow pattern.

I should say there is one more, equally important area of basic research in aerodynamics, and that is one I have completely neglected so far in this article. It is the phenomenon of *turbulence* and the aerodynamics of *turbulent flows*. The word *turbulence* is used to describe the completely irregular flow that occurs in pipes carrying water at high speed, and in many other practical setups. It is due to the small, but nevertheless important, viscosity of a fluid. You have all seen something similar in watching the smoke of a cigarette rising in still air. It rises steadily in a smooth filament for a while, and suddenly breaks up into a confused and irregular eddying motion. Figure 9 shows three sketches of Osborne Reynolds' famous experiment on flow of water in a tube. If

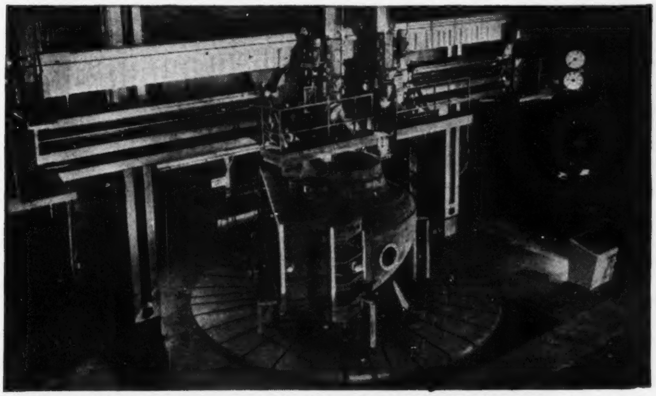
(*Continued on page* 28)

Behind Every Success There's
PLANNING


H. V. FULLER

by H. V. FULLER, *Supt. Time Study and Planning Dept.*
General Machinery Division, ALLIS-CHALMERS MANUFACTURING COMPANY (*Graduate Training Course 1939*)

PLANNING is an important part of manufacturing machinery—and of building a career, too. This planning, however, must be based on information and experience. You don't always have all the facts about industry that you need at the time you leave engineering school and start planning your own future. At least, that's the way it was with me when I got my degree in Mechanical Engineering at University of Wisconsin in 1936.


New 30-ft. boring mill now operating in Allis-Chalmers' West Allis shops. It supplements older, slower 40 ft. mill, and greatly increases capacity on big, heavy work. Both mills are scheduled practically around the clock, seven days a week.

I took a job with a big manufacturer, but within a year the work I was doing ended, and my employers referred me to the Allis-Chalmers Graduate Training Course. I enrolled in 1937—and then my knowledge of industry really began to grow. There was the usual round of the plant—shops, offices, various departments—where I saw a wide range of work at first hand. I worked with steam turbines, pump testing, and on the electrical test floor. About half way through the two-year course I got really interested in the manufacturing side of the business. After four months of plant layout work I went to the Time Study and Planning Department, and finished out my course there in 1939. In 1945 I became Superintendent.

This Is the Starting Point

In this department we really start the manufacturing operation. We're given the engineering drawings and material specifications. And from this data we plan the sequence of manufacturing operations—determine the equipment and tooling required, and set up time standards for each operation.

You can get some idea of the volume of work from the fact that our West Allis Machinery Division shops ship an average of eight million pounds of finished machinery per month—representing a range of products from small V-belt sheaves to massive crushers, steam and hydraulic turbo-generating units, cement kilns, sewage pumps, motors, flour mills, and power transformers.

Look Before You Decide

As a Graduate Training Course engineer here you may become interested in manufacturing. There's a great need for trained engineers in this work. Or, you may find your interest lies in some other field—designing, research, sales, personnel, service and erection. In any case, the Graduate Training Course gives you a chance to look them all over, gain practical first-hand experience, plan your career on a sound basis of knowledge.

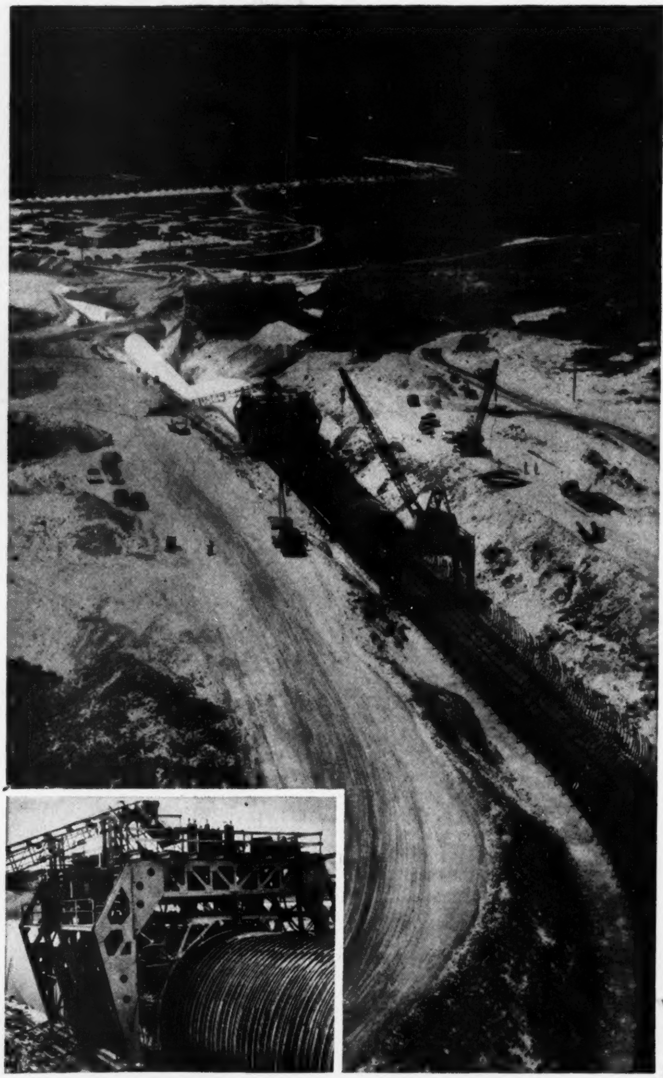
Do Your Own Planning

The course is flexible—you help plan it yourself and can change it as new interests or opportunities develop. There's no other spot in industry that offers such a wide range of experience—so many choices for a career.

If you want to get further details as to qualifications, salary and operation of the course, get in touch with any Allis-Chalmers district office. Probably the manager was a G T C himself. Or, write for literature.


One of the three 6000 kw 3-machine Allis-Chalmers motor-generator sets in large Eastern steel mill. These units provide direct current for motors driving 68-inch hot strip mill.

ALLIS-CHALMERS *Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin*



Aerodynamic Theory

(*Continued from page 24*)

the entrance is smooth and rounded and the flow rate not too high, the flow is *laminar*. A thin stream of dye injected into the flow passes downstream as a smooth and regular filament, as sketched. But at higher flow speeds this regular flow is replaced by the irregular eddying motion known as *turbulence*; the dye filament is broken up and dispersed into the fluid.

Boundary Layer Turbulent

Why is an aerodynamicist interested in this? It is not that the atmosphere is turbulent (though it is), for its eddies are so big that they affect aircraft principally as a series of gusts. More important to us is the fact that the *boundary layer* is often turbulent itself. Even when most of the stream is smooth and regular, the boundary layer is found to consist of a fine-scale, irregular, turbulent motion. This is of tremendous importance because the turbulence produces a much more rapid exchange of momentum (i.e., friction) and heat (transfer) than occurs in a laminar layer. Thus, turbulent boundary layers are undesirable as regards friction drag, but they have greater resistance to separation, whether due to shock waves or less violent phenomena, and so they are often desirable.

Figure 10. Oscillograms showing speed records taken simultaneously outside (upper) and inside (lower) the boundary layer, at the same downstream station.

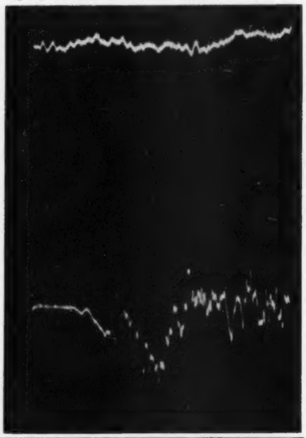


Figure 10 presents two oscillograms (taken by the hot-wire-anemometer technique) showing the speed records outside and inside the boundary layer in a wind tunnel. The respective laminar and turbulent characters are clearly seen. The intensity of turbulent fluctuations is 90 times as great in the lower record as in the upper.

The Future

To this date, our understanding of such turbulent boundary layers, or even simpler turbulent flows, is very meager. We need much basic research to determine how the boundary layer becomes turbulent, how it develops, how energy is taken from the main stream to make turbulence—especially in the presence of pressure gradients. This is one of the major subjects of research in our Graduate School of Aeronautical Engineering.

In the title of this article, I promised to make some predictions about the future of aerodynamics. When we finish our research on strong shock waves and gases at high temperatures, and on turbulence, what radical improvements in aeronautics will become possible?

Part of this I can answer. We will reduce to practice the flight of aircraft at very high speeds and altitudes. An understanding of turbulence and turbulent boundary layers will make possible many refinements of design of aircraft and their engines, including the realm of combustion.

But these are hardly exciting predictions. Where are the flying saucers and the Buck Rogers space ships? The answer is, of course, that they may lie ahead of us, but that none of us has the vision to see just what clever inventions will bring them into reality. We can be sure, nevertheless, that these inventions *will* be based on better understanding than we now possess of the frontier regions of aerodynamics.

We at Cornell are attacking this situation from both sides. We are doing the basic research necessary to achieve this understanding, and we are educating the bright young engineers who will make the inventions.

News of the College

(*Continued from page* 20)

ment of Hydraulics in the School of Civil Engineering.

For the past two years, Professor Jorrissen has been in charge of the hydraulics laboratory at Pennsylvania State College and taught fluid mechanics and related subjects. In 1948 he was scientific advisor to the Laboratoire Central d'Hydraulique, in Paris.

He was formerly an advanced fellow under the Belgian American Educational Foundation in the study of American fluid mechanics laboratories and the design and construction of a new hydraulics laboratory at the University of Liege in Belgium.

Professor Jorissen recently attended a meeting of the Committee on Fluid Meters of the International Organization for Standardization, in Paris, France.

Joint Laboratory

A pioneering venture in educational and industrial research cooperation has been revealed here in a plan announced jointly by the General Electric Company and Cornell University for the establishment of an advanced electronics center at Ithaca, believed to be the first of its kind in the nation.

Initially, the center will occupy a large modernized laboratory building located on Cornell property adjacent to the Ithaca East Hill airport. Modification of the building, already begun, is scheduled to be complete by February, 1952. Employment at the center during its first year of operation is expected to reach 80 people, more than half of them scientists.

The project's over-all purpose, as outlined by G-E and Cornell officials, "is to carry out advanced study and development in the field of electronics, and at the same time provide scientists and engineers with teaching and educational opportunities of a type never previously established."

They cited as an immediate objective of the new center, an attempt "to fulfill the rapidly increasing needs of both industry and the armed services for additional military electronics research and development facilities." It will supplement the company's electronics research activities at Electronics Park, Syracuse, and at Schenectady, N.Y.

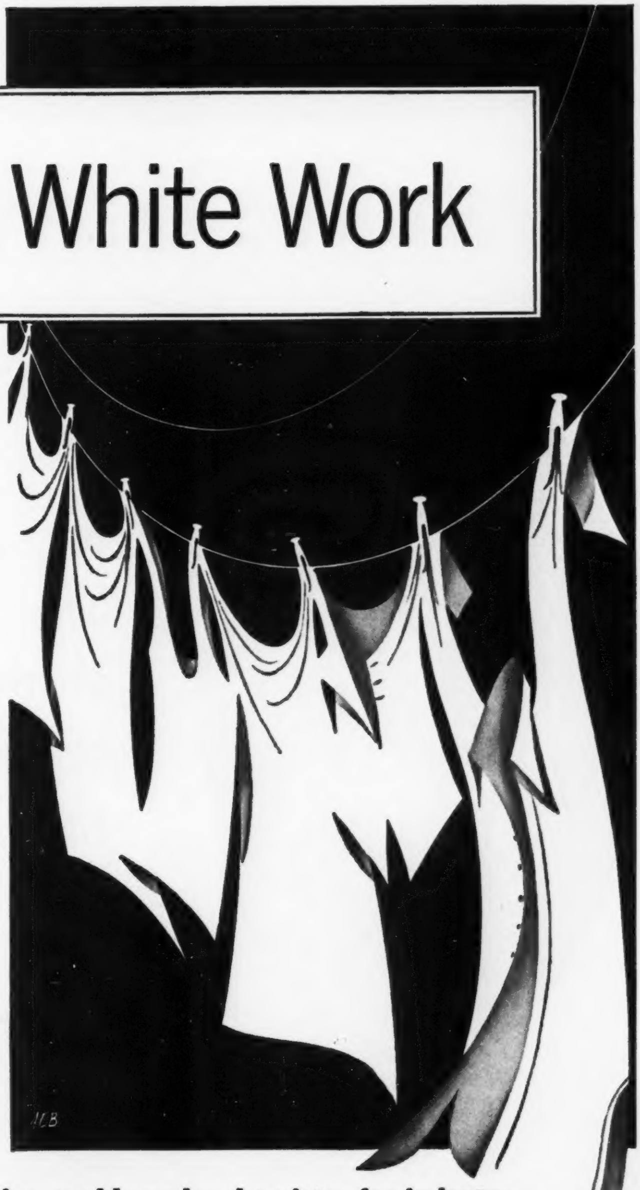
Projects to be carried on at the center during the present national emergency may include the development of such items as control systems for guided missiles, electronic counter-measures, and infra-red systems, officials said.

Plans for the project, to be known as the General Electric Advanced Electronics Center at Cornell University, have been made over the past few months by Dr. W. R. G. Baker, G-E vice-president and general manager of its Electronics Division, and Dr. S. C. Hollister, Dean of the College of Engineering of Cornell.

Activities at the center will be directed by a four-man management team—two men of industry and two men of science. Their combined skills and experience represent fully the abilities required in the various scientific, industrial, military, and academic aspects of such a pioneer venture.

(*Continued on page* 34)

Whiter White Work



CHEMICAL PROBLEM...

. . . laundry detergents to wash clothes whiter without increasing laundering costs.

SOLUTION...

. . . a Hercules cellulose derivative called CMC-CT . . . a special form of cellulose gum. Now a standard ingredient in many leading brands of "soapless soaps," its unique action floats dirt away from the clothes and prevents it from getting back during the wash, thereby improving whiteness.

COLLEGE MEN...

This is but one example of the far-reaching chemical developments in which you could participate at Hercules—in research, production, sales, or staff operations. It suggests the ways Hercules' products serve an ever-broadening range of industries and end-uses.

Hercules' business is solving problems by chemistry for industry...

. . . paint, varnish, lacquer, textiles, paper, rubber, insecticides, adhesives, soaps, detergents, plastics, to name a few, use Hercules synthetic resins, cellulose products, terpene chemicals, rosin and rosin derivatives, chlorinated products, and other chemical processing materials. Hercules explosives serve mining, quarrying, construction, seismograph projects everywhere

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Modern industrial research must constantly explore far beyond outposts of the known. For through this tireless reaching past existing scientific frontiers, the impossible of today becomes the reality of tomorrow.

The Howard Hughes Fellowships in Science and Engineering were established at the California Institute of Technology to encourage such creative industrial research and development. Any American citizen is eligible for a Fellowship who qualifies for graduate standing at the Institute for study toward the degree of Doctor of Philosophy with a major in physics or engineering.

Each Fellowship covers a twelve-month period. A portion of it is spent in advanced work in the Research and Development Laboratories of Hughes Aircraft Company. A Fellowship award provides a money gift, salary, and tuition and research expenses.

Dr. Clark Millikan (left) of the California Institute of Technology welcomes to the campus Hughes Fellowship recipients Art Bryson from Illinois and Warren Mathews from New Jersey.

News of the College

(*Continued from page* 30)

Representatives of Cornell will have a definite part in the approval of projects to be assigned to the center by General Electric.

Cornell will give faculty appointments to a number of staff members of the center, in accordance with their qualificatoins. They will be granted full faculty privileges on the campus, and may be used by the university to teach appropriate classes. Their work at the G-E center will be arranged so that such teaching assignments at Cornell will not be interrupted by their laboratory work for the company. Library and other facilities normally available to the Cornell faculty will be made available to the G-E staff.

Certain members of the staff and faculty at Cornell may be employed by the General Electric Company on a part-time salary basis or as consultants.

Graduate and fifth-year students at Cornell may be employed on a part-time basis to perform work at the G-E center. Graduate students working at the center may also conduct work on their graduate theses or dissertations by mutual agreement of representatives of the university and the company.

Temporary space will be provided at Cornell for G-E personnel working on projects connected with the new electronics center, until modifications of the laboratory buildings are complete.

Resident manager of the center at Ithaca is H. R. Oldfield, Jr., a General Electric executive since his separation from the U.S. Air Force in 1945.

Associate principal scientist at the center is Dr. Charles R. Burrows, director of the School of Electrical Engineering at Cornell. Dr. Burrows will continue his present duties in addition to representing Cornell on the management team.

The principal scientist for the center will be announced at a later date.

Dean's List

Each year the College of Engineering announces a "Dean's Honor List." This rating is given to students with a average of eighty-five or better. This year one hundred and thirty-eight undergraduates were included. This is from a total engineering enrollment of somewhat over fifteen hundred, meaning about nine percent of the student body recieved the honor. Last year's Honor students, according to their colleges, follow:

School of Chemical Engineering: William H. Abraham, '52; Seymour M. Blinder, '55; Stanley R. Byron, '55; Menelo J. Carlos, '53; Elliott R. Caterulla, '54; Donald E. Danly, '52; John S. Gordon, '53; Charles D. Graham, '52; Joseph A. Gryson, '54; Julian P. Heicklen, '54; William C. Johnson, '54; John P. Jones, '53; Martin L. Kasbohm, '52; Irwin A. Kaufman, '55; James J. Klien, '55; Marshall Lapp, '55; Edward R. McDowell, '55; Richard J. Mayer, '55; Robert M. Messner, '53; David J.

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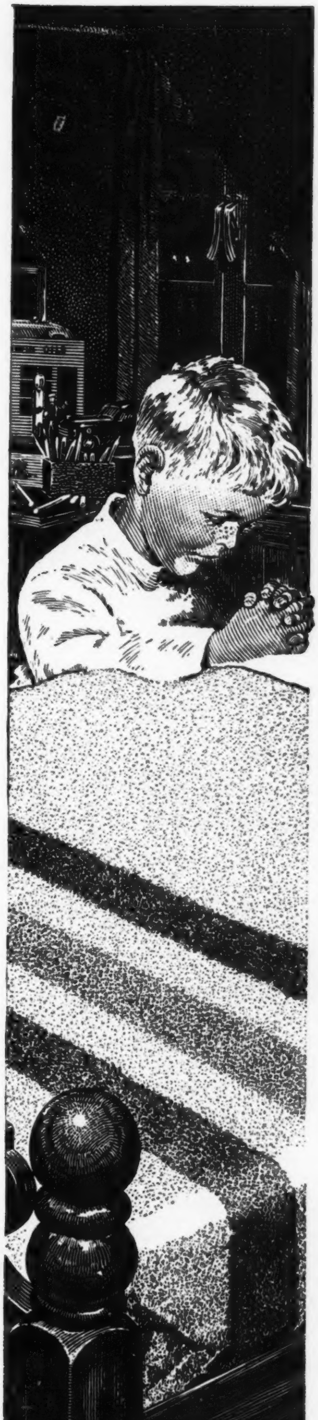

News of the College

(*Continued from page* 34)

Nerrow, '55; Robert O. Osborne, '55; Robert B. Polak, '55; Kenneth W. Powers, '53; Leonard B. Rothfeld, '55; John F. Schmutz, '55; David A. Thomas, '53; Henry C. Thorne, Jr. '52; James D. Verbsky, '55; Maxwell R. Warden, '55; Robert H. Williams, '55; Kendrick E. Zinn, '55.

School of Civil Engineering: Ralph M. Baumgarten, '52; Wallace K. Bishop, '52; Walter S. Bortko, '52; Robert E. Fitzner, '52; Myal C. Greene, '53; Herman A. J. Kuhn, '53; Alden L. Malanson, '53; John M. Morgan, '52; James J. O'Brien, '52; Daniel L. Pope, '53; Joseph E. Prickett, '55; Robert C. Ready, '54; Robert M. Shapiro, '54; Donald E. Unbekant, '53; Ralph J. Vichill, '55.

School of Electrical Engineering: John R. Arnold, '54; Charles E. Baun, '53; Robert M. Bierman, '53; Gerald M. Bloom, '55; Alan R. Carlson, '52; George J. Cockcroft, '55; Thomas F. Deutsch, '55; Thomas O. Duff, '54; Lester F. Eastman, '53; George D. Edwards, '55; Robert Z. Fowler, '54; Victor H. Ham, '52; Peter L. Jenner, '53; George T. Kraemer, '54; Stuart N. Levy, '55; Addams S. McAllister, '55; Lyle E. McBride, '52; Merton D. Meeker, Jr., '53; Leonard E. Mende, '55; Howard W. Mitchell, '55; David W. Nast, '53; John M. Pew, '52; Robert T. Sinacore, '55; William J. Smithers, '53; Robert M. Stock, '54; Edward A. Collins, '52; Mary A. Diegert, '52; Peter H. Pincoffs, '52; Charles D. Simmons, Jr., '52.

School of Engineering Physics: Janice Button, '54; Frank D. Drake, '52; Harold H. Edwards, '55; Arthur S. Gregory, '55; Peter Goldman, '52; Luther H. Haibt, '54; Walter A. Harrison, '53; Robert J. Hartlieb, '52; Robert L. Hoeppel, '54; Robert E. Hufnagel, '55; Irving Itzkan, '52; Alan M. Jacobs, '55; William S. Jewell, '54; Walter L. Jones, '55; Neal F. Jordan, '55; Ben Josphson, '53; David P. Lieb, '53; James D. Livingston, '52; Malcolm D. McIlroy, '54; Dietrich Meyerhofer, '54; James S. Myamoto, '55; Donald E. Ordway, '53; Harry E. Petschek, '52; Howard M. Rathbun, '55; Richard J. Rosa, '53; Murray E. Sherry, '55; Donald C. Stevens, '55; Ralph R. Stevens, '54; Paul P. Whalen, '54; William D. Bentley, '54.

School of Mechanical Engineering: John W. Abbott, '55; James B. Anderson, '55; Thomas H. Arnott, '55; Robert L. Bael, '55; James R. Baum, '52; James M. Beveridge, '53; John A. Blesch, '55; Robert W. Breckenridge, '55; Clyde W. Burdick, '54; Ascher Chase, '54; Richard W. Cowing, '54; William C. Cowing, '55; George H. Dalsheimer, '55; Vincent DiGrande, '55; Alan Q. Eschenroeder, '55; William J. D. Escher, '54; David L. Cohoe, '52; Don S. Follett, '53; Donald C. Franklin, '55; Allen E. Galson, '53; J. Richard Gauthy, '55; Charles R. Glassey, '53; Phillip F. Gottling, '52; Donald F. Griffin, '52; Richard H. Hillsley, '54; Robert V. Kahle, '55; Charles W. Metzler, '53; John J. McGarigal, '52; Henry

(*Continued on page* 38)

German crowd, part of the 1,250,000 from East and West Berlin, sees a typical RCA television program.

"Freedom's window in the Iron Curtain"

You've read the story of last summer's TV demonstrations in Berlin. It attracted a million and a quarter Germans – including thousands who slipped through the Iron Curtain to see Western progress at work.

Behind this is another story: How RCA engineers and technicians broke all records in setting up these Berlin facilities. The project called for a TV station and studio, a lofty batwing antenna, and the installation of 110 television receivers at strategic points. Such a program would normally take several months to complete. It was installed and put to work by RCA in a record-breaking 85 hours!

Programs witnessed by Berliners included live talent shows, sports events, news commentaries, and dramatizations of the Marshall Plan. Observers pronounced reception fully up to American standards – another impressive demonstration of democracy's technical ingenuity and leadership.

• • •

See the latest wonders of radio, television, and electronics at RCA Exhibition Hall, 36 West 49th St., New York. Admission is free. Radio Corporation of America, RCA Building, Radio City, New York 20, N. Y.

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Graduate Electrical Engineers: RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

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Write today to College Relations Division, RCA Victor, Camden, New Jersey. **Also many opportunities for Mechanical and Chemical Engineers and Physicists.**

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News of the College

(*Continued from page* 36)

E. Maurer, '54; Warren Minners, '55; John C. Phifer, '52; David Pratt, '55; Robert N. Quade, '55; Robert C. Reisweber, '53; Donald E. Richards, '55; Samuel E. Rogers, '52; Robert Gray Rutishauser, '54; Robert S. Stahr, '52; Sherwood S. Strong, '55; George W. Sutton, '52; Robert A. Vanderhoek, '54; Barry L. Weiss, '54; Hugh H. Whitney, '55.

American Society for Metals

The Silver anniversary of the Southern Tier Chapter of the American Society for Metals was observed at a dinner meeting November 12 at Cornell. A certificate of commemoration was presented by William H. Eisenman, executive secretary of the society. Walter E. Jominy, staff engineer of the Chrysler Corporation and a former president of the society then gave an address on "Applications of Hardenability." The local group represents more than one hundred members drawn from the metal working industries of Ithaca, Binghamton, Corning, Elmira, Endicott, Athens, Pa., and Scranton. Cornell takes an active part in the chapter activities, having representation both by faculty members and by a student group.

Professor Contra Returns

After a five year absence, during which time he held a professorship at Syracuse University, Professor J. B. Conta has returned to the mechanical engineering faculty. His return augments the heat-power department, in which he was an associate professor prior to his leave. Another addition to the faculty is Assistant Professor R. L. Wehe, in machine design.

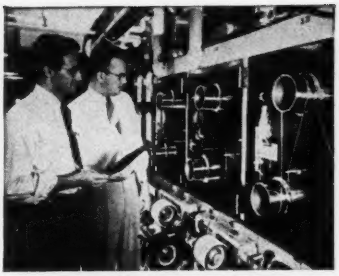
Books Published

Two publications by Engineering faculty members have recently been announced. Professor Arthur McNair of the School of Civil Engineering is finishing a book on geodesy for the United States Army. The second publication was made by the National Advisory Committee for Aeronautics from a report by Professors DuBois, Mabie, and Ocvirk of the School of Mechanical Engineering. The report dealt with their "Experimental Investigation of Oil Film Distribution for Misaligned Plain Bearings." This is one of several reports turned out recently by these men, most of which are classified.

ASEE Convention

Professors Beard, Cleary, and Siegfried attended the annual meeting of the American Society of Engineering Education this fall, where they presented a paper at the Mechanical Drawing seminar. Professor Loberg, Director of the School of Mechanical Engineering also gave an address at the meeting on Sales Engineering. The American Society of Mechanical Engineering also heard a paper by a Cornell faculty member at its annual meeting in November. Professor Saunders gave a report on "Production Project Work for Industrial Engineering."

THE DU PONT DIGEST



F. E. SPELLMAN, JR., *B.S.M.E., M.M.E., Ohio State '51, and D. A. Smith, B.S.M.E., Purdue '40, discuss a change in feed wheel design of nylon spinning machine.*

M.E.'s AT DU PONT [3]

Plant engineering and production supervision offer interesting careers for science graduates

In the past two issues of the *Digest* you've read of the broad opportunities that are offered mechanical engineers in research and development work at Du Pont.

This month let's look at opportunities for men interested in any of the branches of plant engineering—such as maintenance, power, design and construction—or in production supervision.

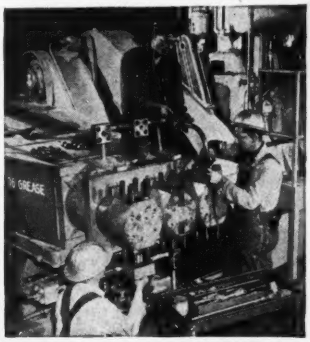
Efficient maintenance is an important cost factor in the continuous processes of a modern chemical industry. The M.E. is called upon to diagnose troubles, work out corrective measures, and supervise repairs.

Frequently he increases production by developing preventive maintenance measures. So vital is this work that in one division of the Company, 500 men of all crafts, along with a routine maintenance group, spend almost all their time on it.

One example of the problems facing Du Pont engineers is the maintenance of pumps made to tolerances of 0.0001" and operating at pressures up to 6000 p.s.i.

A FIREMAN *adjusts louvers for the proper combustion of pulverized coal. Blown into furnace through pipes, it burns at 2500°F.*

In power work, also, problems requiring application of mechanical engineering principles arise. For instance, a metal required in one chemical process is melted at 800°F. by immersion heaters fired by butane, which is expensive. Conversion to fuel oil presented the problem of complete combustion in the immersion chamber. Du Pont M.E.'s redesigned the heaters so combustion could be complete and the hot gases recycled in water to use all the available heat.



OVERHAUL *on polythene area injection pump is six-hour job for three men. Work must be scheduled for minimum disruption of output.*

In design and construction of chemical plants, mechanical engineering again is of major importance because of the wide variety of plants built and intricacy of their equipment. Engineers collect basic data, design and select equipment. They also supervise many steps of construction until the plant is operating.

Production supervision attracts many mechanical engineers. Men who have the ability and interest usually move into it by one or two routes: they acquire background on all stages of a plant's operations by helping design the plant, or by operating on the job.

MAINTENANCE TEAM *making a speedy change of a methanol valve to minimize production loss.*

Sometimes students of mechanical engineering feel that in a chemical company they will be overshadowed by chemical personnel. This is not the case at Du Pont. Here, hundreds of administrators and supervisors, up to the rank of vice-president, started as M.E.'s.

Opportunities for men and women with many types of training are described in the 40-page brochure "The Du Pont Company and the College Graduate." For your free copy, address 2521 Nemours Bldg., Wilmington, Del.

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Detergents

(*Continued from page* 12)

shown that one of them, namely cetyl-trimethyl bromide, in 0.03% concentration is sufficient to kill rapidly virulent strains of *Staphylococcus aureus* and *Streptococcus pyogenes* in the absence of organic matter such as blood or pus. The quaternary ammonium compounds are considerably more active in neutral or alkaline solution than in acid solution. They do not interfere with the healing processes or cause irritation. Occasional sensitivity has been reported. The main medical use of these compounds has been the sterilization of surgeons' hands in gloveless surgery and in obstetrics.

"Arquad S" manufactured by Armour and Company is coming into wide usage for sanitizing in the frozen citrus concentrate industry. Tests have shown this compound to kill most organisms at a dilution of one part of active material to 30,000 parts of water in the prescribed FDA phenol coefficient test method. However, according to current commercial practice, a concentration of five times stronger than that, or one part in 6,000, has been considered a practical dilution for use. Even with higher concentrations allowing a greater safety factor, the cost is extremely low. This compound has been found readily adaptable to production line work.

Sulphur Introduced

A recent development has been the introduction of sulphonamide grouping into the quaternary ammonium compounds. Sulphathiazole, sulphadiazine and sulphamerazine have been incorporated into the anion of cetyltrimethyl-ammonium, cetyl pyridium, and lauryl pyridinium. In 1948, quaternary ammonium compounds were synthesized in which the sulphonamide was part of the cation. The compounds are antibacterial because of the quaternary ammonium component and not because of the sulphonamide.

Although emphasis has been placed upon the special "cationic" characteristics of cation-active agents, they also show the usual

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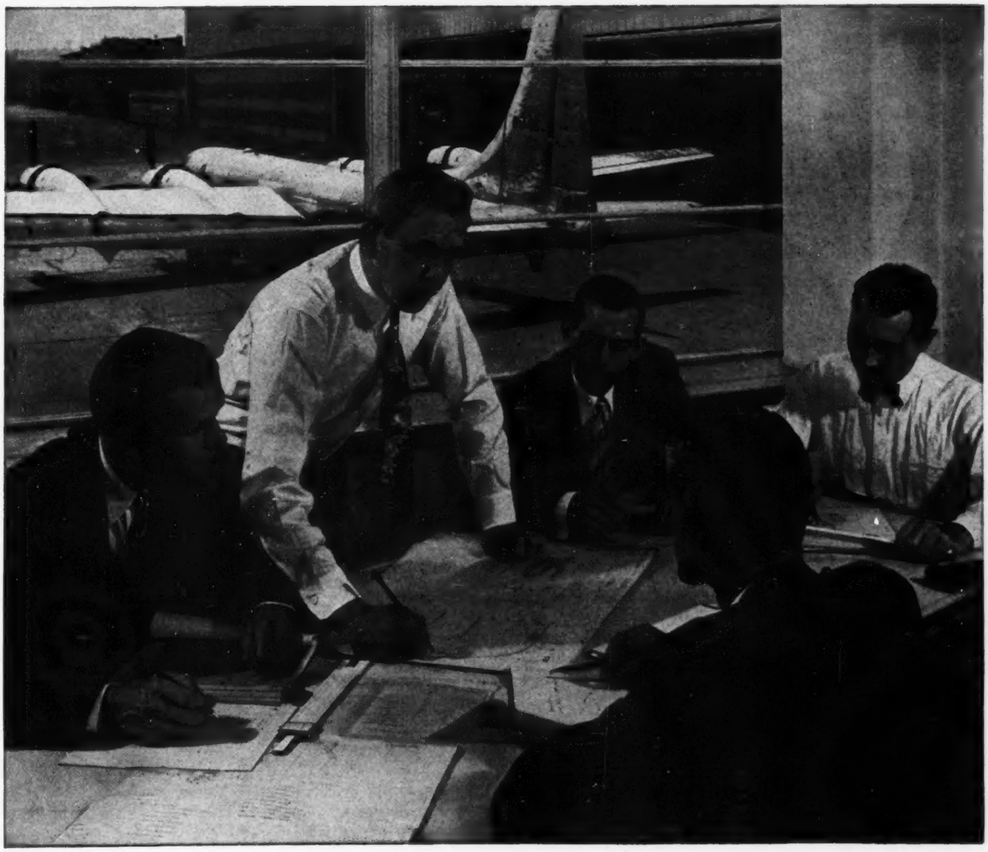


Detergents

(*Continued from page* 40)

properties of surface-active agents, such as setting, foaming, emulsifying, and detergent ability. On the other hand, cationic agents are not compatible with anion-active agents, because the high molecular weight cations and anions combine to form insoluble, inactive compounds. But both are compatible with the non-ionic type.

To date, cationic detergents have been unsuccessful in breaking into the household detergent field. While the competition is stiff among manufacturers of anionic detergents, this is not so in the cationic field, owing to the smaller number and select usage of these materials. It is important to note, however, that among the cationic detergents probably 75 per cent may be described as quaternary ammonium salts of which the compound, alkyl-dimethyl-benzyl ammonium chloride bulks large.

The tendency has been to divide the cationic detergents sharply into detergents for special textile and other uses, and germicidal agents which in general comprise the quaternary ammonium salts. Although the latter do lower surface tension and act as wetting agents to some extent, it is considered more desirable to add additional non-ionics to them to increase their detergent qualities where such addition is useful in the application desired. This has created a considerable market for non-ionic detergents.

Many Producers

During the latter part of 1949, around 750 different trade-name detergents were on the market. Of these, only 75 belonged to the cationic class. No one company seems to have taken control of the field, for there are twenty-six principal cationic detergent producers in the United States.

It is quite clear that the entire synthetic detergent field is one of intense economic competion. One important principle to remember when considering the price fluctuations of detergents is that they compete with soap, which is inherently cheap under normal conditions. Therefore, detergents must either do a better job than soaps, in order to command a premium price, or they must do the same or better job at the same price. This adds up to the fact that detergents do have an economic ceiling which is fixed by the price of soap. Many sellers of raw materials set their prices on the comparison of soap costs and completely forget that in order to utilize present day detergent molecules other expensive ingredients must be added in substantial amounts in order to make the detergents effective. However, synthetic detergents have made great strides because they do a better job than soap in hard waters, and it is surprising to note that they are finding widespread acceptance in soft water areas.

(In the second of the two parts of this discussion, the author will discuss the chemistry and the industrial technology of cationic detergents.)—Weber.

New Look In Electronics

(*Continued from page* 15)

sistor without mentioning some of its present limitations. The elimination of a relatively high noise level is one problem which transistor research must deal with. At 1000 cps most of the units measured so far have a noise figure between 10 and 20 db. It is hoped that new transistors which are now being planned will reduce this figure considerably. Perhaps of even greater importance is the frequency limitation of the transistor. Studies indicate that collector capacitance limits the frequency response at full gain to a few kilocycles. However, by judicious circuit design this response can be increased to at least one megacycle. What is important though, is that this frequency limitation is not an inherent one and will probably be considerably improved in the future.

The title of this article suggests changes, and the materiel presented gives some idea of the nature of these changes. It is apparent that the future of electronics and its effects on society must now be considered as vastly different than a similar consideration made several years ago. The imminent electronic revolution can be appreciated by its effect on industry, the public and in education.

In industry can be seen a tremendous improvement in the complexity of computing and other machines which were limited in the past by problems of power consumption, life-span of integral parts, and accuracy in performance of these same units. A comparison of the brain with computing machines of the future creates an interesting philosophical sideline of transistor electronics. Present day computing devices such as the Eniac computor are 1,000,000 times less complex than the brain but accomplish individual processes 1000 times faster, thus being in total 1000 times less competent. By replacing tubes with transistors it may be possible to add to the complexity of the computor by the factor of 100 or more. This would leave the machine only one tenth as efficient as the brain with the possibility for even further improvement not outside the realm of possibility.

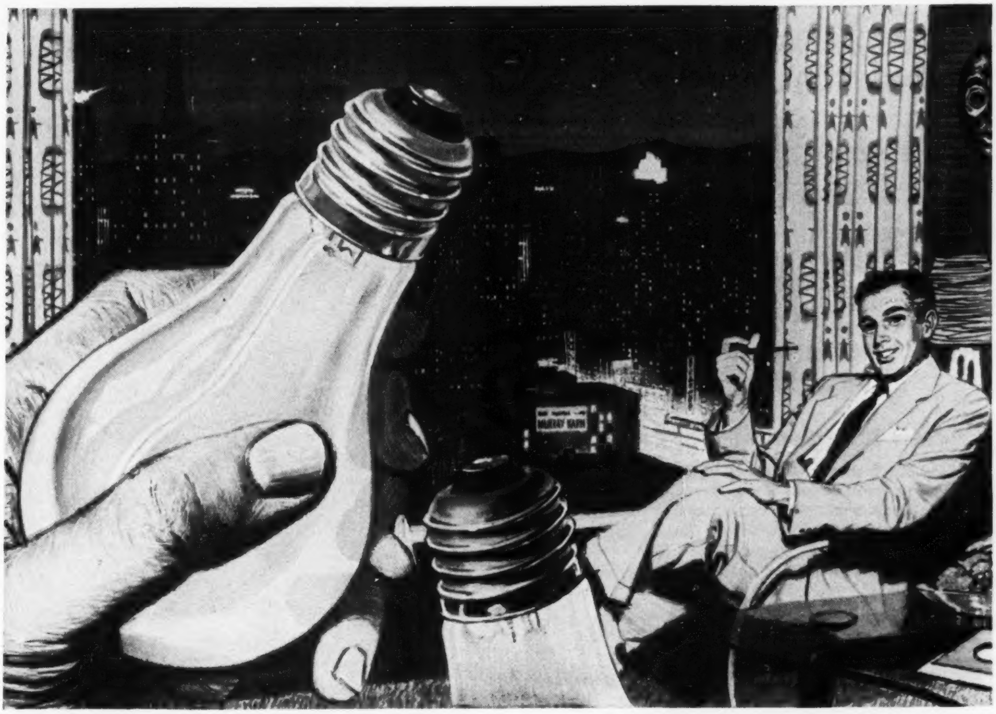
With transistors replacing tubes, factories will be built and reconverted and workers will learn new trades and skills. New materials will become economically important and new industrial processes will arise as needed. As in all new industries, quick action may raise a heretofore unknown to industrial power with the consequent slipping of an established industrial giant. In other words, a small scale industrial revolution may be anticipated.

Predictions

The public will benefit most directly from these changes. All electronic equipment will eventually cost less than comparable units today. The further increase in the life of equipment will also mean less expenditure to the public. If we get as far as a complete reconversion of the electronic industry there will not only be a shifting of jobs but an actual increase in the number of positions available. And finally, we will see the availability to the public of devices previously thought to be too complex for introduction to the home, the latter made possible by the saving in space and power consumption, qualities inherent in the transistor.

In education too, revamping must be done to keep up with this progress. Electronics courses would of necessity have to be planned using transistors, their characteristics and their own equivalent circuits. The field of semi-conductors and their application to industry will become more important in college curricula and there will be a temporary lag in basic electronic research at educational institutions until those concerned will become up to date in this new field.

Today we stand on the threshold of great changes in industry and in our lives. Science has again forged ahead just as one of its mainstays has seemed to reach its maximum productivity. The past achievement of electronics forms a great record in science. It is not too presumptuous to assume that the transistor which replaces the vacuum tube will create in the future a record no dimmer than the past.


MARKET MAPS

Alumni News

(*Continued from page* 19)

which was published in the November 1951 issue of the WESTINGHOUSE ENGINEER. He lives at 204 Western Ave., Albany, New York.

V. L. Dzwonszyk, E.E. '35, has been appointed Operating Sponsor reporting to the Operating Vice-President of the American Gas and Electric Service Corporation. He is an instructor in the Evening School of Pratt Institute of Technology, in Brooklyn, N. Y. He is a member of A.I.E.E., I.E.S., Cornell Society of Engineers and Eta Kappa Nu.

E. R. Urquhart, E.E. '39, holds a Lieutenant Colonel's commission in the Army Ordance Corps. He is now the Post Ordance Officer, Camp Hanford, Washington, site of the Hanford Atomic Engineering Works.

Mrs. Vivian Hoffman Grey, M.E. '47, M.SinE. '49, is director of public relations and publicity for a Hollywood television and radio firm. Recently she has been appearing in plays at the Pasadena Playhouse and in Hollywood and is also writting local West Coast television programs. She and her husband, Jerry Grey '47, are in Hollywood until he completes work for his PhD in aeronautics at the California Institute of Technology.

Richard H. Allen, B.M.E. '45, '47, is resident engineer with the Crosley division of Avco Manufacturing Co. in St. Louis, Mo. A son, Nicholas John Allen, was born last November 1. The Allens live at 6007 Columbia Avenue, St. Louis.

John J. Christenson, B.Chem.E. '46, '49, is a trouble-shooter for the vice-president in charge of production of the Commercial Solvents Corp.

Norbert W. Burlis, B.E.E. '47 is an electrical engineer with Emerson Electric Manufacturing Co. in St. Louis, Mo. He is also a partner in the Custom Engineering & Development Co., making electronic medical instruments. His address is 6910 Eugene, St. Louis 16, Mo.

Ralph E. Peters, B.C.E. '49, of 836 Lower Ferry Road, Trenton, N. J., is a highway designer with Richardson & Gordon, 1411 Walnut Street, Philadelphia, Pa.

Douglas M. Cameron, B.E.E. '50, has been made technical assistant to the superintendent of the meter and installation department of Consolidated Gas and Electric Co. in Baltimore, Md. He lives at 216 Ridgewood Rd., Baltimore 10.

Vincent C. Oxley, B.E.E. '50, is an electronic engineer for Bell Aircraft in their guided missile program. He lives at 127 Highview Rd., Buffalo 21.

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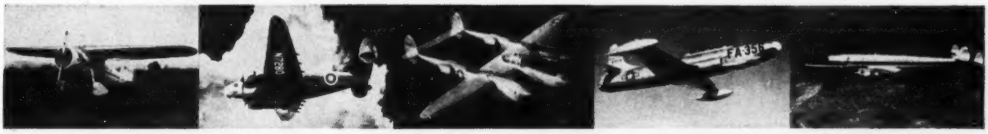
great future

YOUR FUTURE

There's a better future—a better job—waiting for engineers at Lockheed Aircraft Corporation, in beautiful San Fernando Valley. At Lockheed you are well-paid from the start; work in modern, air-conditioned offices; receive training that prepares you for promotion—you are part of a team known for **leadership in aviation.***

These Lockheed planes show why Lockheed—and Lockheed engineers—earned that reputation for leadership:



THE VEGA— flown to fame by Charles Lindbergh, Amelia Earhart, Wiley Post.

THE HUDSON BOMBER— first American plane to fight in World War II.

THE P-38 LIGHTNING— first 400 mile-per-hour fighter-interceptor.

THE F-94— first all-weather jet interceptor assigned to duty with America's aerial defense forces.

THE SUPER CONSTELLATION— larger, faster, more powerful; the plane that bridges the gap between modern air transport and commercial jet transport.

The jet of the future—the plane you will help create—belongs in this frame. There will always be empty frames like this, waiting to be filled by Lockheed engineers. That's why Lockheed will always need forward-looking engineers. So why not make Lockheed's great future **your** future. See your placement officer for illustrated brochures explaining work—and life—at Lockheed.

If your placement officer is out of brochures, write:

M. V. Mattson
Employment Manager
LOCKHEED
AIRCRAFT CORPORATION
Burbank, California

***Aeronautical training is not necessary; Lockheed will train you.**

Technibriefs

(*Continued from page* 16)

possible the use of the isotope on large areas and on deep or otherwise inaccessible cancers. By way of comparison for the duplication of the radiation of the cobalt 60 to be used in this apparatus, it would require $26,000,000 worth of radium.

The apparatus consists of a housing and electrical-mechanical system that makes it possible for doctors to give radio-active treatments to patients by remote control, to limit the amount of radiation to the patient, and to return the source to a safe position in case of power failure. The isotope is encased in a special tungsten alloy which is less transparent to radiation than lead. The operator, located in an adjacent room, is protected from radiation by a thick concrete wall, but can observe the patient through a window consisting of fifteen inches of x-ray resistant material.

Although this new apparatus does not promise any sure cure for cancer it is certain that its use will be of great aid in the fight against the disease.

Titanium Tetrachloride

The DuPont Pigments Department has been working on the application of titanium tetrachloride to industrial, military, and domestic uses. Titanium tetrachloride is a compound similar in structure to carbon tetrachloride, the well known cleaning fluid and fire extinguisher. It is derived from the metal titanium, which though not quite so strong as stainless steel, is lighter and far more resistant to corrosion.

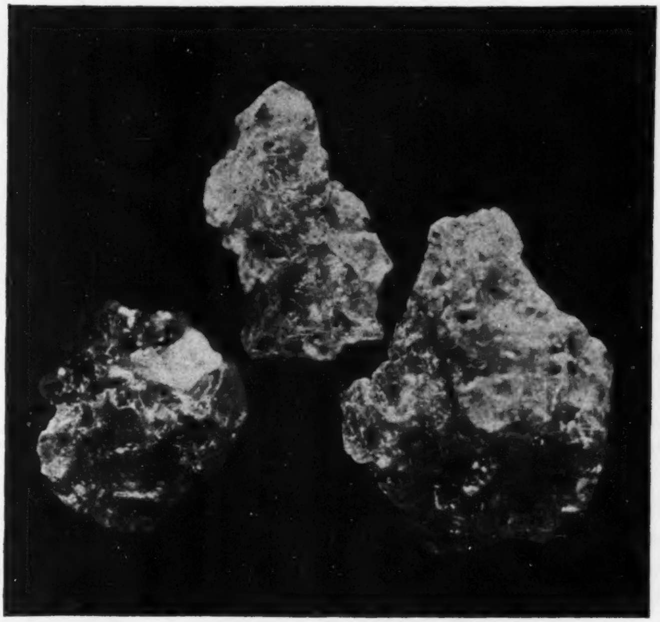
The first use of titanium tetrachloride has been in the making of new experimental fireproof paints which would be of great value in reducing the hazard of fire aboard ships at sea. Although the problems of adherence and corrosion resistance are yet unsolved, this paint shows great promise of becoming a boon to all American vessels in the prevention of the spreading of fire from one compartment to the next by heating of the walls to such high temperature that the paint catches fire.

A second use is the making of Erifon flame retardent. This material is a solution of titanium tetrachloride and antimony chloride in water. When applied to a fabric and allowed to dry, an amorphorus mixed oxide is bonded chemically to the fibers, producing flame resistance that lasts through repeated laundering or dry cleaning, and does not adversely affect the texture or appearance of the mateiral. This retardant is especially effective with drape material. Most of DuPont's production goes to the army for fireproofing tents. Its use cuts the weight of tents nearly eighteen percent under the weight of tents processed by other tested method.

A third use has been in the production of sponge titanium by mixing the tetrachloride with molten magnesium which reduces titanium to the metal. This sponge can then be cast, forged, rolled, or drawn into desired shapes.

This is a magnification of what abrasive material?

- ☐ *Commercial Diamond*
- ☐ *Fused Silicon Carbide*
- ☐ *Fused Aluminum Oxide*
- ☐ *Boron Carbide*



The answer "Fused Aluminum Oxide" gives you a passing mark. But, it's not just ordinary fused alumina. It's Norton 32 ALUNDUM* abrasive in a single crystal, containing more than 99% pure fused alumina — hailed as the "greatest abrasive contribution to increased grinding production in more than 40 years."

How It's Made

When bauxite is submitted to an extremely high temperature in an electric furnace by an ingenious Norton Process, grains of 32 ALUNDUM abrasive form in a fluid matrix where each grain grows into a single, complete crystal — strong in shape and with many sharp points on all sides. The matrix not only contributes to 32 ALUNDUM abrasive's unique crystalline structure but also absorbs impurities from the melt. This accounts for the better than 99% purity.

The matrix is then dissolved away by a complicated chemical process and the released grains are washed and screened to size. No crushing is necessary.

Amazingly Versatile!

The extra sharpness and crystalline form of Norton 32 ALUNDUM abrasive enables it to grind cast iron, aluminum, bronze, brass, soft steel, high-speed steel and cast alloy tool materials. Its versatility is further borne out by a typical report. In one prominent plant, Norton 32 ALUNDUM wheels, replacing other wheels, accounted for over-all time savings, floor to floor, of: surface grinding — 26.3%; internal grinding — 13.1%; tool grinding — 13.2%; cylindrical grinding — 25%.

Worth Remembering

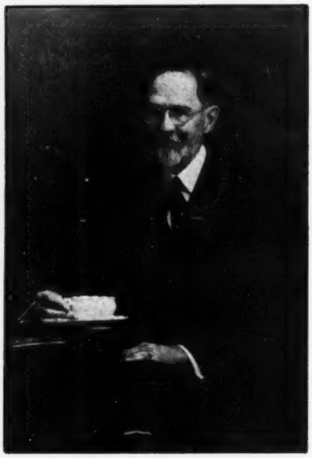
This example of "making better products to make other products better" promises an interesting future to young engineers who want to contribute to new developments. Norton Research is well worth investigating.

Free Folder

highlights the cost-cutting advantages of Norton 32 ALUNDUM abrasive on countless grinding jobs. Write for your copy.

Gordon R. Finlay, Ph.D., Cornell '42, examines a specimen with the Metallograph in the Physical Testing Laboratory at the Norton electric furnace plant in Chippawa, Canada.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries



Whose picture is printed above, when was he last Seen on the Campus, and what is his Connection with the Cornell Engineer?

For the correctly documented Answer, the Engineer will award two Tickets to its Annual Banquet, and a Free Trip to Trumansburg.

STRESS *and* STRAIN...

Sunday drivers had picked the country gentleman's fruit and flowers. One of them pointing to an unexplored highway said to the c. g., "Shall we take this road back to town?"

"You might as well", said the c. g. "You've taken everything else."

* * *

She: "I have a beautiful face, beautiful shoulders, a perfect waist, a perfect bust, and . . . say, are you following me?"

E.E. "Following you! Heck, I'm way ahead of you."

* * *

"I simply gotta divorce this woman," the disconsolate man told the court. "She insists on keeping a goat in our bedroom and the smell is so bad I can't stand it."

"That sounds bad," said the judge, "but couldn't you open a window?"

"What, and let all my pidgeons get out?"

* * *

An Engineer is a person who passes as an exacting expert on the basis of being able to turn out with prolific fortitude infinite strings of incomprehensible formulae calculated with misromatic presision from vague assumptions which are based on debatable figures taken from inconclusive experiments carried out with instruments of problematical accuracy by persons of doubtful ability and questionable mentality for the avowed purpose of annoying and confounding a hopelessly chimerical group of fanatics referred to all too frequently as Engineers.

(Editor's note; A few commas and periods might help, so supply your own.)

* * *

As he felt his way around the lamp post he said, "Shno use. I'm walled in."

O Engineers with hairy ears, designing dams and ditches;
Controlling floods and blowing suds and never reaching riches.
When you want your fun your tastes don't run to graphs and mathematics,
But to a bar that's not to far, and ballroom acrobatics.
You make survey of waterways and plan for irrigation;
But H_2O to gin that's sloe, you add with moderation.
With stress and strain you ascertain the ways to make frames rigid,
Then spend the night till broad daylight in making dames less frigid.
O Engineers have hairy ears—I find them most endearing—
But awfully odd because, by God, they don't like engineering.

* * *

The girl on the bus was reading an article on birth and death statistics. Suddenly she turned to a scholarly looking gentleman sitting beside her and said, "Do you know that every time I breathe, a man dies?"

"Very interesting," the gentleman returned. "By the way, have you tried sen-sen?"

* * *

Boy: "May I have a quarter to see the circus?"

E.P. Father: "I let you see that eclipse last week. Do you want your life to be one perpetual round of gaiety?"

* * *

Sundown found a lonely Indian climbing to the top of a bluff. There he built a fire and began to send smoke signals to his lady friend across the valley. A short while after he had begun an Air Force plane dropped an atomic bomb in the valley between the Indian and his lady fair. "Gosh," said the Indian as he watched the billowing mushroom of smoke, "I wish I'd said that."

I walked into a barber shop,
The sign was very queer.
"During alterations
We will shave you in the rear."

* * *

Here's to the light that lies in a woman's eyes,
And lies, and lies, and lies, and lies, and lies.

* * *

Temperance Lecture: "And in conclusion, my dear students, I shall give a you a demonstration of the evils of the Demon Rum. I have here two glasses, one filled with water, the other with whiskey. I will now place a worm in each glass. Notice how the worm in the water squirms and vibrates with the very spark of life, while the worm in the whiskey writhes in agony, curls up and dies. Now young man, what is the moral of this story?"

"If you don't want worms, drink whiskey."

* * *

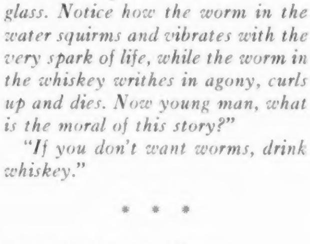
December's Brain-Teaser:

An ME, finding himself short of cash just before a big weekend, sent the following telegram to his father:

SEND
MORE
———
MONEY

If each letter of the telegram stands for a digit, how much money did the ME ask for?

Answer to November's brain-teaser:



QUESTION: ANSWERS:

What are the advantages of working for a large company?

From a poll of college graduates with ten years' experience at General Electric

In order of mentions:

1. *Greater variety of opportunities.* Sample quotes: "More chances of getting into a type of work you will thoroughly enjoy." "Wider choice of jobs." "Plenty of opportunity to find the right job." "There are more opportunities for potential managers than there are candidates." "All sizes of puddles for all sizes of frogs." "More opportunities becoming available due to expansion, transfers, retirements."

2. *Greater opportunity for adjustment,* "G.E. goes out of its way to find the corner you are happiest in and best suited for." "Didn't have to decide on a particular specialty until I had looked the field over." "You can investigate many types of work before choosing your own special field." "Chance to change jobs without losing advantages connected with length of service." "You can change your line of work almost at will without changing employer."

3. *More chance to learn.* "More opportunity to get a good orientation and training program." "Unlimited training." "Better organized and planned training courses." "Opportunity of finding the best of training in my chosen field." "G-E training programs a good bridge between college and industry." "Training from experienced men." "Good chance to learn by association with established experts in many fields."

4. *Greater stability and security.* "Business more stable in large company." "Stability—*if* ability is proven." "Progressive policies concerning pensions, health insurance, etc." "Good security if you do a good job."

5. *Broader sources of information.* "Tremendous wealth of scientific knowledge and information no further away than telephone." "Ease of obtaining technical information, special information, services." "Wealth of knowledge and experience to draw from." "Experts available for consultation." "Access to latest and best technical information and ability."

6. *Better facilities and resources.* "Best technical skills and facilities are available." "Good research facilities and projects." "Better facilities for doing a better job." "Best in equipment and facilities." "If an idea or project is worth while and you sell it, there are adequate resources of men, material and financial backing."

7. *High standard of ethics.* "More honest effort to put value into the product." "Most people I know at G. E. are more interested in building good equipment than in profits by any means." "Fair treatment by management." "Near certainty that you will receive fair treatment." "No fear of relatives of the boss getting *my* promotion."

8. *Chance for greater personal prestige.* "Prestige of working with a company known nationally and internationally." "Friendships all over country among people of your own background and education." "Community recognition."

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